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410B
VACUUM TUBE VOLTMETER

OPERATING AND SERVICE MANUAL

HEWLETT hp PACKARD

HP 410B

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The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

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OPERATING AND SERVICE MANUAL

(HP PART NO. 410B-901)

MODEL 410B
VACUUM TUBE VOLTMETER

SERIALS PREFIXED: 024

Appendix C, Manual Backdating
Changes adapts this manual to
Serials Prefixed:
024-44032 and below, below 024-,
003-31433 and below, Serials 21434-25833,
21433 and below, 04252 and below.

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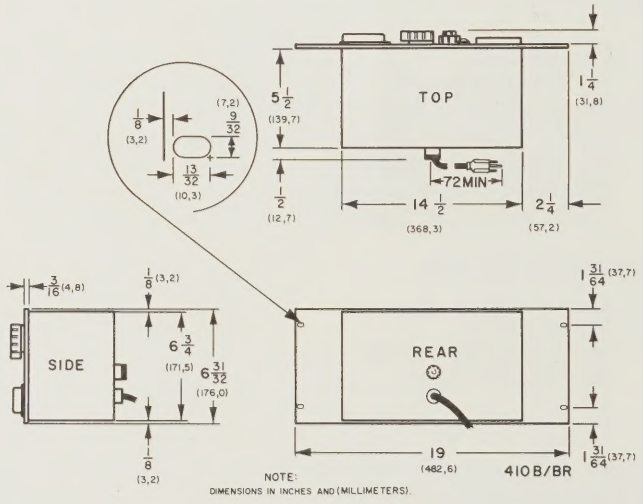
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SPECIFICATIONS

RANGES:	1 to 300 volts full scale in 6 ranges: 1, 3, 10, 30, 100, and 300 volts AC or DC and 0-1000 volt range DC. Resistance 0.2 ohm to 500 megohms in seven ranges. Mid-scale reading of 10, 100, 1,000, 10,000, 100,000 ohms, 1 megohm, and 10 megohms.
ACCURACY:	±3% of full scale on all ranges on sinusoidal AC voltages and DC voltages. The AC portion of the instrument is a peak-reading device, calibrated in rms volts. Ohmmeter accuracy is ±1 ohm at mid-scale of RX1 range, ±5% at mid-scale of all other ranges.
FREQUENCY RESPONSE:	Frequency response is flat within ±1 db up to 700 mc and drops off less than 1 db at 20 cps. Probe resonant frequency is about 1,250 mc and an indication can be obtained up to 3,000 mc.
INPUT IMPEDANCE:	Input capacity is 1.5 pf; input resistance is 10 megohms at low frequencies. At high frequencies resistance drops off due to dielectric losses. DC input resistance is approximately 122 megohms for all ranges.
PROBE:	The probe is approximately 1" (2.54 cm) diameter and 4-1/2" (9.4 cm) long. It is equipped with a ground clip, and the connector may be soldered to the point under test. Adapting connectors are available to measure voltages in coaxial transmission lines.
POWER SUPPLY:	115/230 volts ±10%, 50/1,000 cps, 40 watts.
SIZE:	Cabinet Mount: 11-1/2" (29.2 cm) high, 7-3/8" (18.7 cm) wide, 8-3/4" (22.2 cm) deep. Compartment at rear of instrument stores probe and test leads when not in use.
WEIGHT:	Cabinet Mount: 12 lbs.(5.4 kg); shipping weight approximately (7.65kg) Rack Mount: 12 lbs.(5.4 kg); shipping weight approximately (9.0 kg)
RACK MOUNTING:	Available on standard RETMA 7" x 19" panel.



ACCESSORIES AVAILABLE:

11039A Capacitive Voltage Divider, 25 KV max., requires 11018A Adapter.
11040A Capacitive Voltage Divider, 2 KV max.
11042A Probe Coaxial "T" Connector, for Type "N" systems.
11044A DC Resistive Voltage Divider, 30 KV max.
11043A Coaxial "N" Connector, adapts to Type "N" systems.



410B Vacuum Tube Voltmeter

WARNING

The a-c probe shell, the common ground clip lead, the instrument chassis and cabinet, and the green grounding lead in the three-conductor power cable are electrically connected together at all times. When the NEMA connector is used in the proper manner, a ground path is established between the 410B and equipment which is also grounded. Do not connect the ground clip lead or the a-c probe body to any point which is not at ground potential because a short circuit will be created. If such a measurement is necessary, disconnect the NEMA ground in the power cable by using an adapter with the grounding pig-tail removed, and the cabinet insulated from ground. THE 410B CABINET WILL BE AT THE SAME POTENTIAL AS THE NEGATIVE CLIP LEAD. CAUTION MUST BE USED IF THE CLIP LEAD IS CONNECTED TO A POINT WHICH IS MORE THAN A FEW VOLTS OFF GROUND. BECAUSE OF THE POTENTIAL HAZARD TO PERSONNEL, THIS METHOD IS NOT RECOMMENDED.

One side of almost all power distribution systems is grounded. Extreme caution must be used if direct measurement of power system voltages is attempted. If the ground clip lead is accidentally connected to the ungrounded side of the line, severe damage to the 410B is possible because of the short circuit created. Power line voltages can be safely measured by using the probe Tip only. Contacting the grounded power conductor will give a reading of 0 volts while contacting the ungrounded lead will give full line voltage reading.

The 410B is designed for the measurement of audio and r-f voltages and is excellent for this purpose. In normal practice these voltages are almost always measured with respect to chassis ground and no concern need be given to grounds. D-C voltages can almost always be determined by measurements with respect to ground, either directly or by subtraction.

SECTION I
GENERAL

1-1 GENERAL DESCRIPTION

The ℗ Model 410B is a laboratory quality volt-ohmmeter that has been especially designed for making accurate voltage measurements in the frequency range from 20 cps to over 700 mc per second, with useful indications at frequencies as high as 1500 megacycles. The instrument has full scale a-c ranges of 1, 3, 10, 30, 100 and 300 volts, with an input resistance of 10 megohms at low frequencies, shunted by 1.5 $\mu\mu$f. Dc ranges are provided with full scale values of 1, 3, 10, 30, 100, 300 and 1,000 volts. The dc input resistance is approximately 122 megohms on all ranges. The ohmmeter ranges have mid-scale values of 10, 100, 1,000, 10,000, 100,000, 1,000,000, and 10,000,000 ohms. Accurate resistance readings from 1 ohm to 500 megohms are easily made.

The meter scale calibration is very straight forward. All dc voltage ranges and ac ranges 10 volts and above are read on two black scales calibrated 0-1 and 0-3. Due to non linearity of the diode at very low voltages, the 1 and 3 volt ac ranges are read on special, separate, red scales.

All resistance readings are made on one OHMS scale. Figure 1-1 is a drawing of the 410B meter scales.

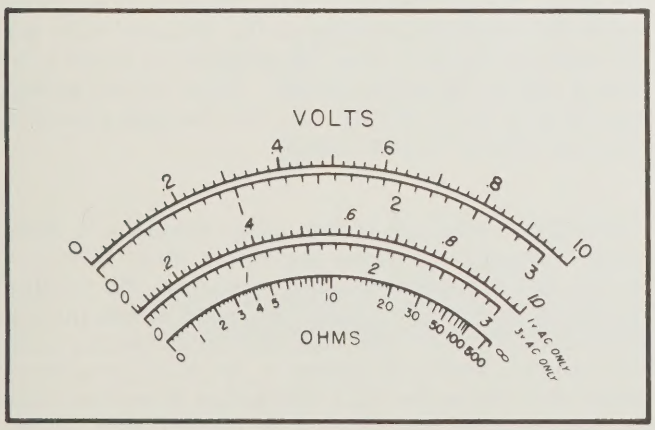


Figure 1-1. Meter Scale Calibration ℗ 410B

Power for the ohmmeter circuits is supplied by the instrument power supply which eliminates the necessity of using any battery with its attendent maintenance.

The high accuracy obtained with all voltage measurements makes the ℗ Model 410B useful for a wide variety of laboratory and field applications, especially in high frequency work. Construction of the a-c probe is such as to enable the operator to minimize lead length and input capacity, factors which usually restrict the high frequency range in instruments of this type. The wide range of a-c and d-c voltage and resistance measurements combined with convenience of operation make the 410B very useful for all types of circuit testing and trouble shooting as well as development work.

1-2 POWER LINE VOLTAGE

When the instrument leaves the factory, the dual 115 volt primary windings of the power transformer are connected in parallel for operation from a nominal 115 volt source. If operation from a nominal 230 volt supply is desired, the windings may be easily reconnected in series. Refer to the schematic drawing for details. Install the correct power line fuse as listed in the Table of Replaceable Parts.

1-3 THREE CONDUCTOR POWER CABLE

The three conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin, WHICH GROUNDS THE INSTRUMENT CHASSIS when used with the appropriate receptacle. To use the NEMA connector

in a standard two-contact receptacle, a three-prong to two-prong adapter should be used. The ground connection emerges from the adapter as a short lead which should be connected to a suitable ground for the protection of operating personnel.

1-4 ACCESSORIES

The 410B is not furnished with any accessories, however a number of special accessories are made by ℗ which extend the a-c and d-c voltage range of the instrument and facilitate a-c measurements in coaxial systems. A description of these accessories and their specifications is contained below; the accessories are shown in Figure 1-2.

a. ℗ Model 11040A Capacitive Voltage Divider
The Model 11040A Capacitive Divider shown in Figure 1-2a extends the a-c voltage range of the 410B Multimeter to 2000 volts rms. The divider is for use at frequencies above 10 kilocycles. Voltage division is 100:1, ±1%, and the input capacity is approximately 2 micromicrofarads.

b. ℗ Model 11039A Capacitive Voltage Divider
The Model 11039A Capacitive Divider shown in Figure 1-2b extends the a-c voltage range of the 410B Multimeter to as much as 25 kilovolts. This divider permits measurement of extremely high a-c voltages such as are encounterd in dielectric heating equipment and similar applications. The frequency range of the divider is from 25 cps to 20 mc, although as frequency increases, the divider is de-rated to limit the r-f current flowing through its capacitors. A fixed gap is provided so that breakdown will occur if the applied voltage exceeds about 28 kv at low frequencies. Voltage division is 1000:1, ±3%, and the input capacity is 15 micromicrofarads. An adapter, ℗ 11018 A, is also required to connect the 410B AC probe to the shielded banana plug fitting of the 11039A. (The 11039A fitting is designed for use with a 400 D type meter.)

c. ℗ Model 11043A Probe Coaxial "N" Connector
The Model 11043A coaxial connector shown in Figure 1-2c allows the a-c probe of the 410B Multimeter to be connected to a 50-ohm coaxial line. The connector uses a female type N connector and a receptacle for receiving the a-c probe of the 410B voltmeter. No terminating resistor is included.

d. ℗ Model 11042A Coaxial "T" Connector
For measurements at the higher frequencies the special T-joint shown in Figure 1-2d has been designed for connecting the 410B Multimeter across a 50-ohm transmission line using type N connectors. The T-joint has been designed so that the connection of the multimeter into a transmission line circuit will not cause a standing wave ratio greater than 1.1 at 500 megacycles and 1.2 at 1000 megacycles. With the aid of this device, measurement of power traveling through a transmission line may be made with reasonable accuracy to 1000 mc. The usual precautions must be taken to provide accurate impedance matching and the elimination of standing waves along the line through which power is flowing. By using a dummy load at the receiving end of this T-joint, power output of various devices can be measured. In many applications power going into a real load, such as an antenna, can be conveniently measured up to frequencies as high as 1000 megacycles with good accuracy.

e. ℗ Model 11044A DC Resistive Voltage Divider
The Model 11044A dc voltage divider shown in Figure 1-2e extends the dc voltage range of the ℗ Model 410B to a maximum of 30 kilovolts. Division ratio is 100:1, ±5%, and the input impedance is 12,000 megohms. This probe offers maximum safety and convenience for measuring high voltages such as in television equipment, etc. The maximum circuit loading is 2.5 microamperes.

1-5 INITIAL ASSEMBLY OF THE PROBE ASSEMBLY

The 410B is shipped from the factory with the probe assembly packed in a compartment accessible by removal of the rear cover. The banana-plug connector should be plugged into the bottom of the instrument and secured with the two machine screws.

1-6 METER MOVEMENT MECHANICAL ZERO

Whenever the meter pointer does not indicate exactly on zero, the pointer should be reset to zero. For most accurate positioning of the pointer, turn the instrument on for about 15 minutes to allow it to reach operating temperature. Turn off the power and wait at least 30 seconds for the capacitors in the instrument to discharge.

The adjust screw is in the meter frame at a midpoint immediately below the meter face. The adjustment is made properly only when the pointer is traveling in the opposite direction to the turn of the adjust screw. Although the adjust screw may be turned in either direction, a practical procedure is to turn the screw in a clockwise direction until the pointer starts to swing back toward zero. Then, still turning the screw clockwise, bring the pointer (now traveling counterclockwise), back to zero.



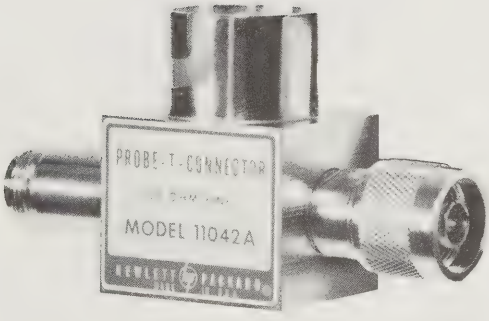
1-2a -hp- Model 11040A
Capacitive Voltage Divider



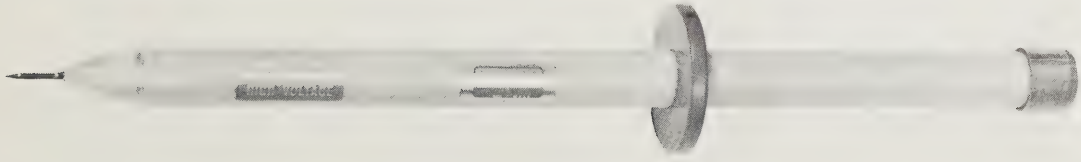
1-2b -hp- Model 11039A
Capacitive Voltage Divider



1-2c -hp- Model 11043A
Probe Coaxial "N"
Connector



1-2d -hp- Model 11042A Coaxial "T" Connector



1-2e -hp- Model 11044A DC Resistive Voltage Divider

Figure 1-2. Accessories for Model 410B

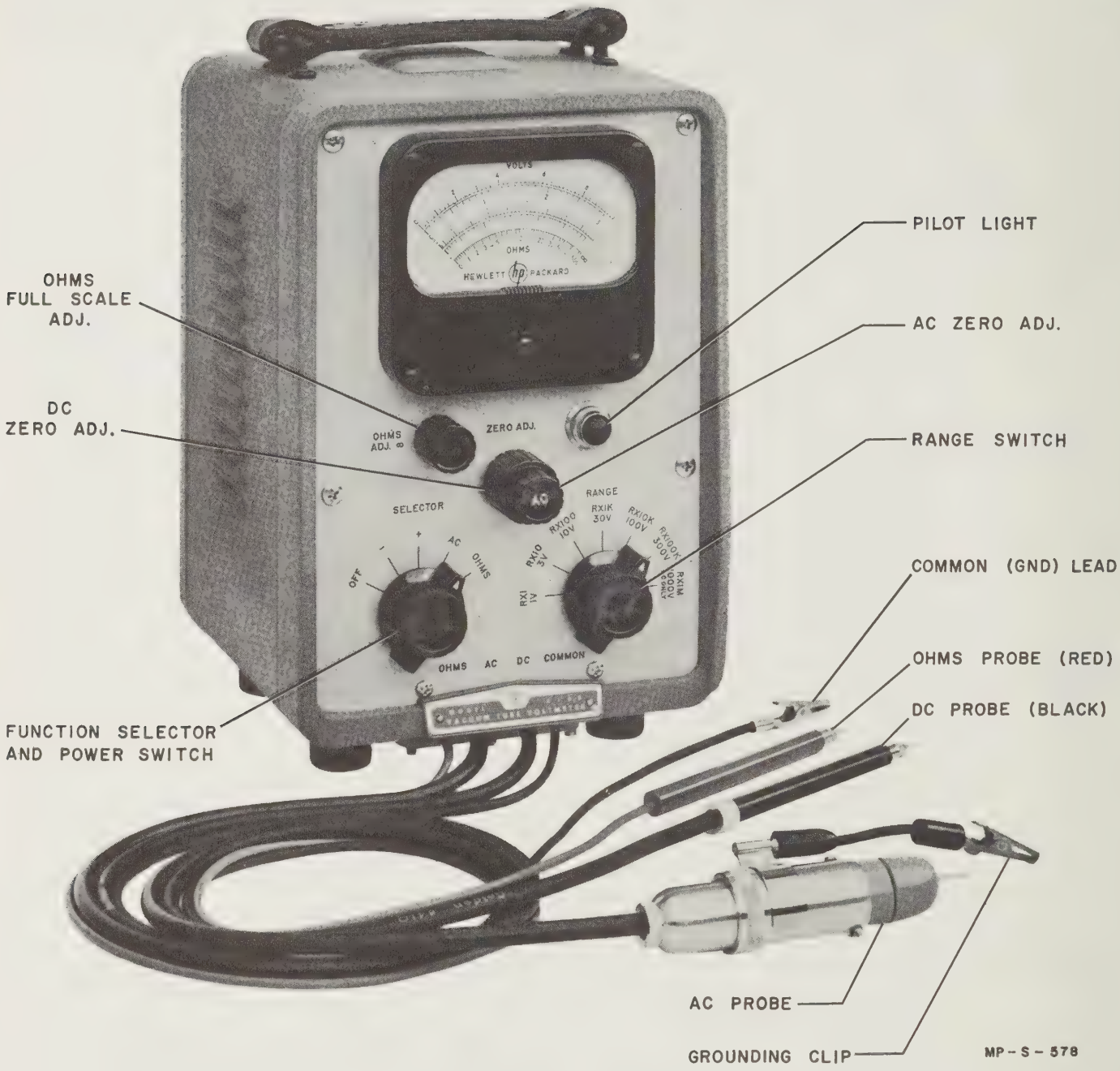


Figure 2-1. Model 410B Controls and Terminals Labeled

SECTION II
OPERATING INSTRUCTIONS

2-1 OPERATING CONTROLS AND TERMINALS

A description of each of the front panel controls, the test probes, and the meter follows:

SELECTOR - This five-position switch turns the instrument on; provides for measurements of negative or positive d-c voltage, a-c voltage, or resistance; and connects the appropriate probe for the desired measurement.

RANGE - This switch selects the full-scale voltage or resistance range to be used.

ZERO ADJ. - The larger, fluted knob is a basic zero adjustment that sets the meter pointer to zero when the SELECTOR switch is set at - and +. The smaller knob marked AC is used to set the meter pointer to zero following the basic zero adjustment and with the SELECTOR switch set to AC.

OHMS ADJ. ∞ - This knob adjusts the meter pointer to full scale (∞) when the SELECTOR switch is set to OHMS.

OHMS, AC, DC, COMMON - The designation at the bottom of the control panel identify the various test leads, which are connected underneath the instrument. The connector can be removed by unscrewing the two captive round head screws in either end of the connector. Once installed, the three probes need not be removed, although only the one probe in use is connected through the SELECTOR switch to the internal circuits. Each probe has the specialized function described below.

OHMS - The red rubber-covered cable with the red plastic prod is used in measuring resistance. The prod is equipped with a small chuck to hold a steel phonograph needle. The instrument is shipped from the factory with the sharp point of the needle inside the chuck and can be reversed if it is necessary to employ a sharp point for good connection. The probe is the negative side of the internal voltage source used for resistance measurements.

AC - A cable that terminates in the shielded probe is used for ac voltage measurements. The probe tip contacts the point in a circuit where a voltage is to be measured and the clip lead on the probe connects to the ground side of the circuit.

DC - The black, shielded cable with the black plastic prod is used to measure d-c voltages. The prod is equipped with a small chuck to hold a steel phonograph needle. The instrument is shipped from the factory with the sharp point of the needle inside the chuck and can be reversed if it is necessary to employ a sharp point for good connection.

COMMON - The black rubber-covered wire terminated in an alligator clip is the negative connection for all measurements except those made with the clip lead on the end of the AC probe. The common lead is connected directly to the chassis of the instrument and to the third grounding conductor in the power cable. When making resistance measurements this lead is positive with respect to the red prod.

FUSE - The fuseholder, located behind the cover in the rear compartment of the instrument, contains a 0.6 amp slow-blow, 115 volt line cartridge fuse replaceable by unscrewing the fuseholder cap and inserting a new fuse. A 0.25 amp slow-blow fuse should be used if the instrument is operated on 230 volts.

2-2 OPERATING ADJUSTMENTS

The ℗ Model 410B has three front panel operating adjustments: ZERO ADJ., AC ZERO ADJ., and OHMS ADJ. ∞. ZERO ADJ. sets the meter pointer to zero when the selector switch is in the - and in the + positions and must be adjusted before the AC and the OHMS adjustments are made. AC ZERO ADJ. adjusts the meter pointer to zero when the selector switch is in the AC position to compensate for any small residual meter reading that appears as the a-c probe is switched into operation. The

AC ZERO should be adjusted when the range switch is on the 1 volt range. OHMS ADJ. ∞ sets the meter pointer to full-scale when the selector switch is turned to the OHMS position.

2-3 STEP-BY-STEP OPERATING PROCEDURES

A. Basic Zero Adjustment

1) Connect the power cable to the power line. Set the SELECTOR switch to the (-) position and allow instrument to heat for five minutes for stable operation.

2) Connect the DC and COMMON test leads together. Adjust the ZERO ADJ. (outer concentric knob) control so that the meter indicates zero with the RANGE switch set to the 1 volt range.

3) Set the SELECTOR switch to + and note the meter reading. If the needle point has shifted, set ZERO ADJ. so that the needle returns to the same position for both - and + positions of the SELECTOR switch.

4) Proper zero set is indicated when the meter zero does not shift when the SELECTOR switch is changed from (+) to (-) and back.

B. AC Zero Adjustment

1) Make the Basic Zero Adjustment described above.

2) Set the SELECTOR switch to AC and set the RANGE switch to the 1 volt position.

3) Connect the AC probe clip lead to the probe tip.

4) Adjust the AC knob to bring the meter pointer to 0.

C. OHMS Full-Scale and Zero Adjustment

1) Make the Basic Zero Adjustment described above.

2) Set the SELECTOR switch to OHMS.

3) Adjust the OHMS ADJ. ∞ control so that the meter pointer indicates ∞ on the ohms scale. The OHMS and COMMON test leads must not be connected together when making this adjustment.

4) To use the ohmmeter without making the basic zero or AC adjustment, connect the OHMS and COMMON test leads together, set the RANGE switch to RX1K or higher range, and adjust the ZERO ADJ. (outside concentric knob) until the meter pointer indicates zero on the ohms scale.

5) With the OHMS test lead not shorted, set the OHMS ADJ. ∞ knob to bring the pointer to ∞.

The multimeter is now ready for operation. Before attempting to make an actual measurement, study the operating procedures described in the paragraphs below.

CAUTION

The voltmeter COMMON, the AC PROBE ground clip lead, the instrument chassis and cabinet are all electrically tied together at all times. In addition, the third (green) lead in the power cable is tied to the chassis. If the three prong NEMA connector is used in a proper mating receptacle, the 410B will be connected to the power system ground. When making voltage measurements, ac or dc, positive or negative, always connect the voltmeter COMMON or the AC PROBE ground clip lead to the chassis, or ground, of the equipment under test. Connecting the ground clip to any other point will automatically ground that point to the power system ground. If a ground path in the equipment under measurement also exists to the power ground, a short circuit will result. If a three-prong to two-prong adapter is used with the pig-tail ground lead disconnected, the cabinet of the 410B will assume the same potential as the point to which the clip lead is connected. For safety's sake, it is best not to make measurements with the ground clip lead connected to points not at chassis potential. In almost every case the measurement can be made successfully by reading the voltages with respect to ground and then subtracting one reading from the other.

2-4 PROCEDURE FOR MEASURING DC VOLTAGES

a. Make the basic zero adjustment described earlier in paragraph 2-3.

b. Set the SELECTOR switch to either the (+) or (-) position, depending upon the polarity of the voltage to be measured.

c. Set the RANGE switch to the range that includes the voltage to be measured.

d. Connect the COMMON test lead to the ground side of the circuit to be measured and touch the DC VOLTS prod to the point in the circuit being measured.

e. Read the measured voltage from the meter, multiplying the indicated value by the appropriate factor. Dc voltages are read from the two top meter scales, 0-1 and 0-3, printed in black.

2-5 PROCEDURES FOR MEASURING AC VOLTAGES

a. Make the AC ZERO adjustment described above.

b. Set the RANGE switch to the range that includes the voltage to be measured.

CAUTION: The ac probe blocking capacitor is rated at 500 volts, do NOT connect the ac probe to higher voltages. Before measuring voltages above 50 megacycles, consult Figure 2-2 a graph of maximum applied voltage vs. frequency. Certain other precautions apply to ac voltage measurements, they are discussed in paragraph 2-8.

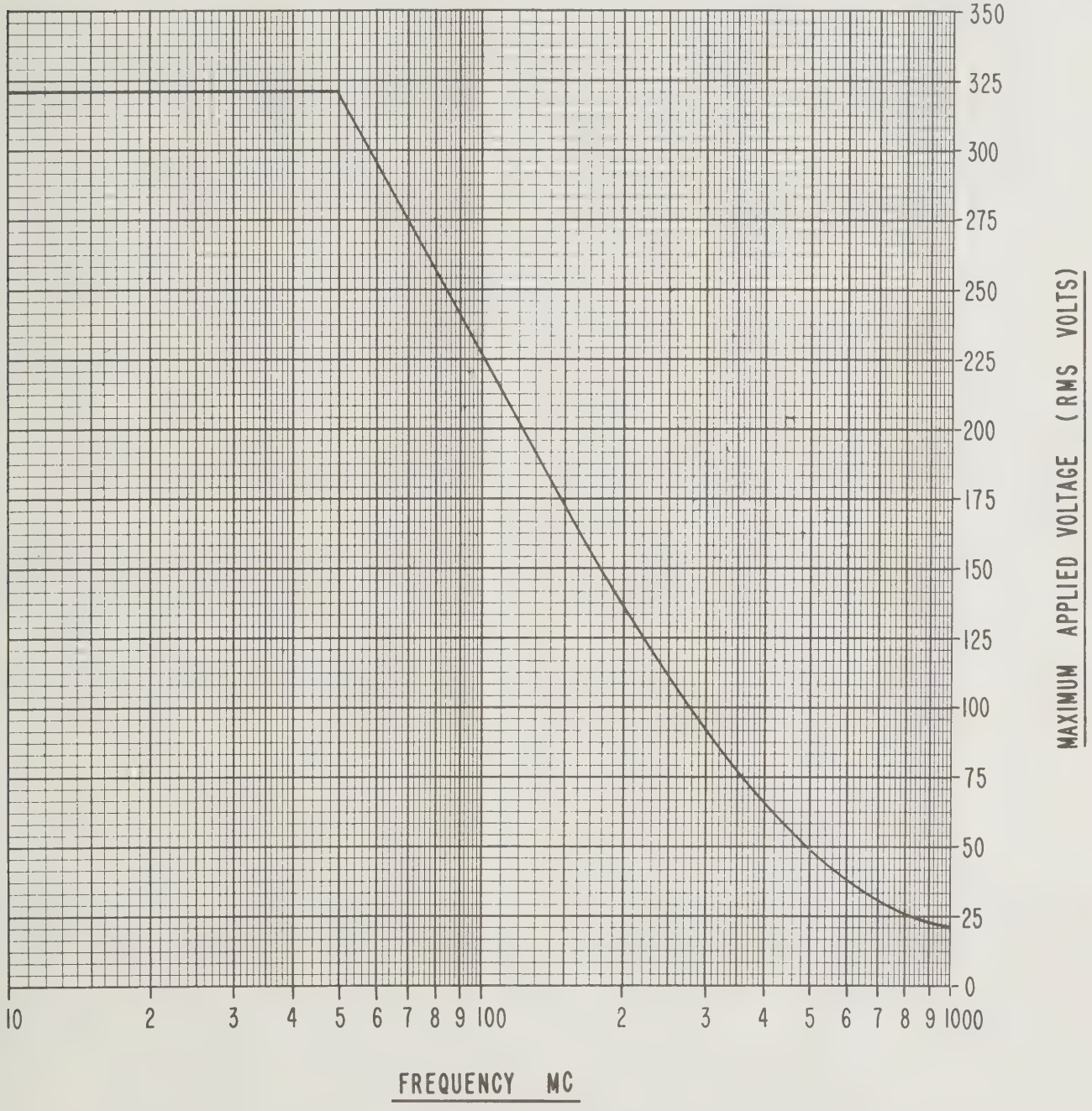


Figure 2-2. Maximum Voltage that can Safely be applied to AC Probe for Frequencies above 50 Megacycles

c. Connect the ground clip lead on the a-c probe to ground of the circuit being measured and touch the a-c probe tip to the other side of the circuit being measured. (For audio frequencies the ground lead from the voltmeter chassis may be used for negative connection instead of the ground lead on the a-c probe, if desired.)

d. The measured voltage is then read from the meter. The full-scale value of the meter is indicated by the setting of the RANGE switch.

NOTE

The 0 - 1V and 0 - 3V meter scales printed in red are for use only with the 1V and 3V a-c positions of the RANGE switch. The remainder of the alternating voltage ranges are read from the two top meter scales (0 - 1 and 0 - 3) printed in black.

2-6 PROCEDURE FOR MEASURING RESISTANCES

CAUTION

TURN OFF EQUIPMENT THAT IS TO BE TESTED BEFORE MAKING RESISTANCE MEASUREMENTS. Be certain that no residual voltages remain in the circuit being measured. When making a leakage resistance measurement on paper capacitors on the RX1Meg range, a reading of greater than ∞ is sometimes measured with the OHMS leads connected one way and a fairly low value of resistance will be measured with the OHMS leads reversed. This is caused by a surface charge in the dielectric of the capacitor which leaks out after the capacitor is first discharged and builds up another slight voltage across the terminals. Since the 410B operates at a very high impedance level, this small voltage will cause erroneous resistance readings. Generally, keeping the capacitor terminals shorted for a few minutes will reduce this charge to zero and a correct reading can be made. This phenomenon will not occur on any of the lower ranges.

a. Make the OHMS adjustment described in paragraph 2-3C.

b. Set the SELECTOR switch to the OHMS position.

c. Connect the COMMON and OHMS test leads to the resistance to be measured.

d. Set the RANGE switch to the position that gives the largest up-scale meter indication.

e. Read resistance value from bottom scale on meter. The resistance is equal to the scale indication times the multiplying factor shown by the position of RANGE selector.

f. Resistance readings up to a million megohms or higher are possible with an external battery. Refer to paragraph 2-10 for details.

2-7 ELECTRICAL CHARACTERISTICS OF THE DIODE AND PROBE

The ℗ Model 410B measures a-c voltages from 1 volt full-scale to 300 volts full-scale in the frequency range from 20 cycles to 60 megacycles and measures reduced voltages to 700 megacycles. The basic accuracy is ±3% for measurement of sine waves up to 60 megacycles per second, while the frequency response is ±1 db over the entire frequency range

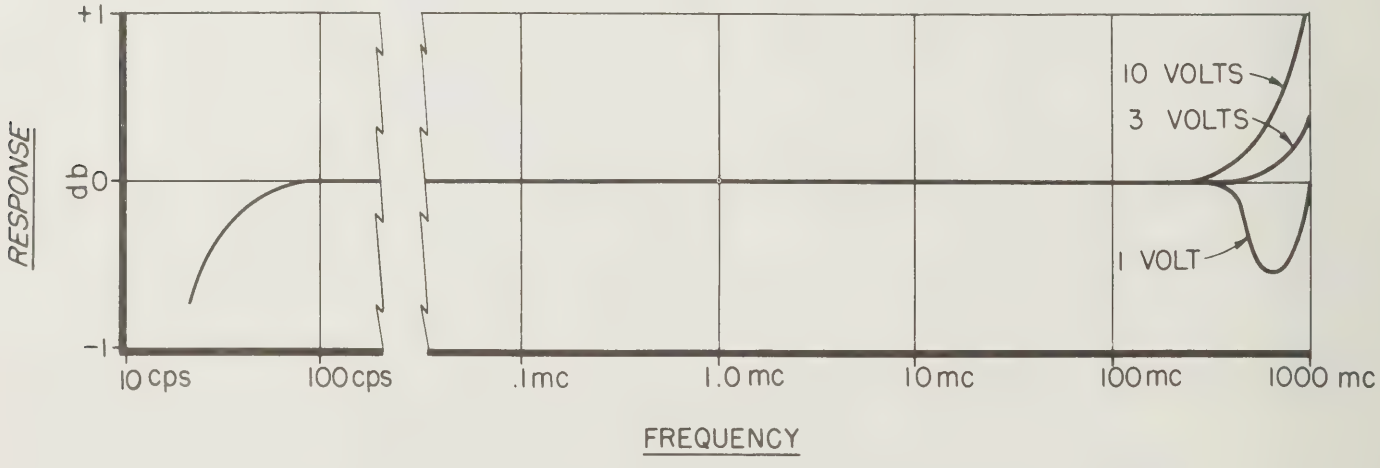


Figure 2-3. Ratio of Indicated to Actual Voltage as a Function of Frequency

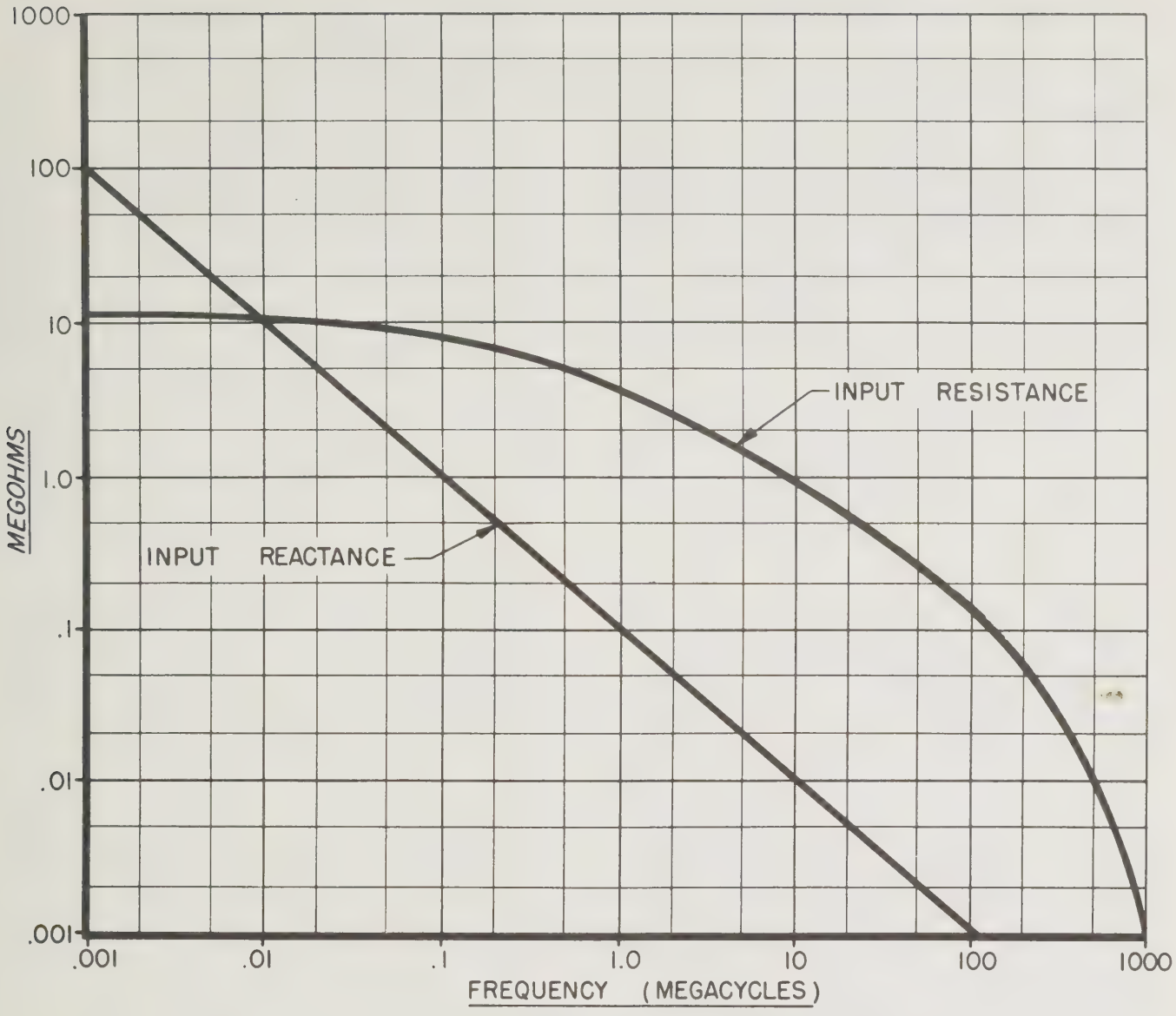


Figure 2-4. Input Resistance and Reactance of Model 410B Diode Probe

from 20 cycles to 700 megacycles per second. The 410B continues to be useful up to the probe resonant frequency of approximately 1250 megacycles, and indications can be obtained up to 3000 megacycles.

A performance curve for the probe, showing the ratio of indicated to actual voltage as a function of frequency, is plotted in Figure 2-3. At low and medium frequencies the response is flat. At high frequencies, however, the response is affected by two factors: transit time of the probe diode, which is dependent upon the magnitude of the applied voltage; and the resonant frequency of the probe, which is independent of the applied voltage. The effect of transit time is indicated by the dip in the 1-volt curve in the vicinity of 500 mc. The rise of the 3-volt and 10-volt curves is due to the effects of resonance in the probe, which overshadow the effects of transit time.

The input resistance and shunt capacitive reactance components in the circuit within the a-c probe are shown in the graph Figure 2-4. At low frequencies the input resistance exceeds 10 megohms, decreasing at higher frequencies because of dielectric and tube losses. The shunt capacity component of input impedance is approximately 1.5 micromicrofarads.

2-8 AC MEASUREMENT PRECAUTIONS

Special considerations must be kept in mind when making a-c voltage measurements. These considerations are discussed in the following paragraphs.

a. General Consideration of Complex Wavforms - Waveforms containing appreciable harmonics or spurious voltages will introduce errors in the meter indication since the meter has been calibrated to read rms values of true sine waves while the a-c probe is a peak-responding device. The magnitude of error that may be expected when harmonics are present on the measured waveform is indicated in the Table below.

Table 2-1. Possible Error when Measuring Voltage of Complex Waveforms

% Harmonic	True RMS Value	Model 410B Indication
0	100	100
10% 2nd	100.5	90 to 110
20% 2nd	102	80 to 120
50% 2nd	112	75 to 150
10% 3rd	100.5	90 to 110
20% 3rd	102	87 to 120
50% 3rd	112	108 to 150

b. Voltage Measurements at Frequencies below 50 Cycles/Second - Voltage measurements at frequencies as low as 10 cycles per second may be made to the unit's basic accuracy by removing the plastic nose on the a-c probe and using in its place a blocking capacitor of 0.25 microfarad in series with the exposed contact of the probe.

CAUTION: The gray insulating material of the probe of the 410B is polystyrene, a low melting-point material. It is not possible to solder to the contact which is exposed when the probe nose is removed without destroying the polystyrene.

c. Voltage Measurements at High Frequencies - At frequencies above 100 megacycles the distance between the point of voltage measurement and the anode contact of the a-c probe must be made as short as possible. If feasible, substitute a small button-type capacitor of approximately 50 micromicrofarads for the removable tip on the a-c probe. Solder one terminal of the button capacitor to the measurement point in the circuit and not to the probe contact. The probe contact (with tip removed) can then contact the other terminal of the capacitor for the measurement.

At frequencies above 100 megacycles considerable voltage may be built up across ground leads and along various parts of a grounding plane. Consequently, to avoid erroneous readings when measuring medium and high frequency circuits, use the ground clip lead on the shell of the probe. In some cases at the higher frequencies it may be necessary to shorten still further the grounding lead on the shell of the probe.

For all measurements at the higher frequencies hold the molded nose of the probe as far from the external ground plane or from objects at ground potential as can conveniently be done. Under typical conditions, this practice will keep the input capacitance several tenths of a micromicrofarad lower than will be obtained otherwise.

For a-c measurements above approximately 250 megacycles it is nearly mandatory that measurements be made on voltages which are confined to coaxial transmission line circuits. For applications of this type, the hp Model 410B is particularly suitable because the physical configuration of the diode and probe is that of a concentric line, and with a few precautions it can be connected to typical coaxial transmission line circuits with little difficulty.

To connect the hp Model 410B into an existing coaxial transmission line, cut the line away so the center conductor of the line is exposed through a hole large enough to clear the body of the voltmeter a-c probe. The nose of the probe should be removed for this type of measurement. Connect one terminal of a button-type capacitor of approximately 50 micromicrofarads to the center conductor of the coaxial line so that the other terminal of the capacitor will contact the anode connection of the probe. A close-fitting metal shield or bushing should be arranged to ground the outer cylinder of the probe to the outer conductor of the transmission line. This type of connection is likely to cause some increase in the standing wave ratio of the line at higher frequencies. The hp Model 455A Coaxial "T" Connector is designed to do this job with a vswr of less than 1.1 at 500 mc. See paragraph 1-5.

d. Effect of Parasitics on Voltage Readings - At frequencies above 500 megacycles, leads or portions of circuits often resonate at frequencies two, three or four times the fundamental of the voltage being measured. These harmonics may cause serious errors in the meter reading. Owing to the resonant rise in the probe circuit at frequencies above 1000 megacycles, the meter may be more sensitive to the harmonics than to the fundamental. To make dependable measurements at these frequencies, the circuits being measured must be free of all parasitics.

e. Effect of DC Present With AC Signal - When measuring small ac voltages, which are present at a point along with high dc potential, you may obtain a voltage reading which is in error. This is caused by a very small leakage current through the blocking capacitor in the tip of the ac probe, and

might occur when you attempt to measure a 1 volt ac signal at the plate of a vacuum tube.

If this leakage is a problem you should add an external blocking capacitor ahead of the probe tip. A Mylar or polystyrene dielectric capacitor of 0.005 μf or larger is recommended. The usual paper or ceramic capacitor will not have sufficiently high leakage resistance to eliminate the problem.

Factory specifications require that the probe tip blocking capacitor have not less than 100,000 megohms resistance, which is the highest value obtainable in a part that meets other requirements. This is very high, but still makes a 1000:1 voltage divider with the 122 megohms input resistance of the meter circuits when on the 1 volt ac range. A 100 volt dc potential will be divided down and will present (approximately) a 0.1 volt signal to the meter circuit. On higher ac ranges, the effect is reduced proportionately.

2-9 PULSE MEASUREMENTS

The 410B is a peak-responding rms calibrated type voltmeter and is designed to measure the positive peak value of the applied voltage. This property allows the hp Model 410B to be used to measure the positive voltage amplitude of a pulse, provided the reading obtained is multiplied by the following factor:

$$1.4\left(1+\frac{t_1}{t_2}+\frac{K}{PRF}\right)$$

where: t_1 is the duration of the positive portion of the voltage in microseconds,

t_2 is the duration of the negative portion of the voltage,

K is a factor which is a function of the source impedance of the pulse generator and of t_1, and is found in the graph of Figure 2-5.

PRF is the pulse repetition frequency in pulses per second.

In general this equation is applicable where the pulse repetition frequency is greater than 500 pulses per second and the positive pulse duration is at least 10 microseconds. For most cases when using high pulse repetition rates, the above factor will reduce to

$$1.4\left(1+\frac{t_1}{t_2}\right)$$

K can be found by use of the curve in Figure 2-5 when the impedance of the pulse generator R_o in kilohms and the duration of the positive portion of the pulse t_1 in microseconds are known.

As an example, suppose:

t_1 = 10 microseconds,

R_o = 2 kilohms and the pulse repetition frequency is 1000 pulses per second,

then $R_o/t_1 = 0.2$, K = 0.55, and the multiplying factor would then be

$$1.4\left(1+\frac{10}{990}+\frac{0.55}{1000}\right).$$

For the case of a 10 microsecond negative pulse and a pulse repetition frequency of 1000 pulses per second, t_1 would be 990 microseconds and t_2 would equal 10 microseconds. Thus, R_o/t_1 would be approximately 0, and therefore (from Figure 2-5) K would also be approximately 0. The multiplying factor would then be

$$1.4\ (1 + 990/10).$$

Hence, it may be seen that in the case of negative pulses of short duration much smaller readings will be obtained than for an equivalent positive pulse. As a result, large multiplying factors must be used and unless the pulse voltage is large, these measurements may be impractical.

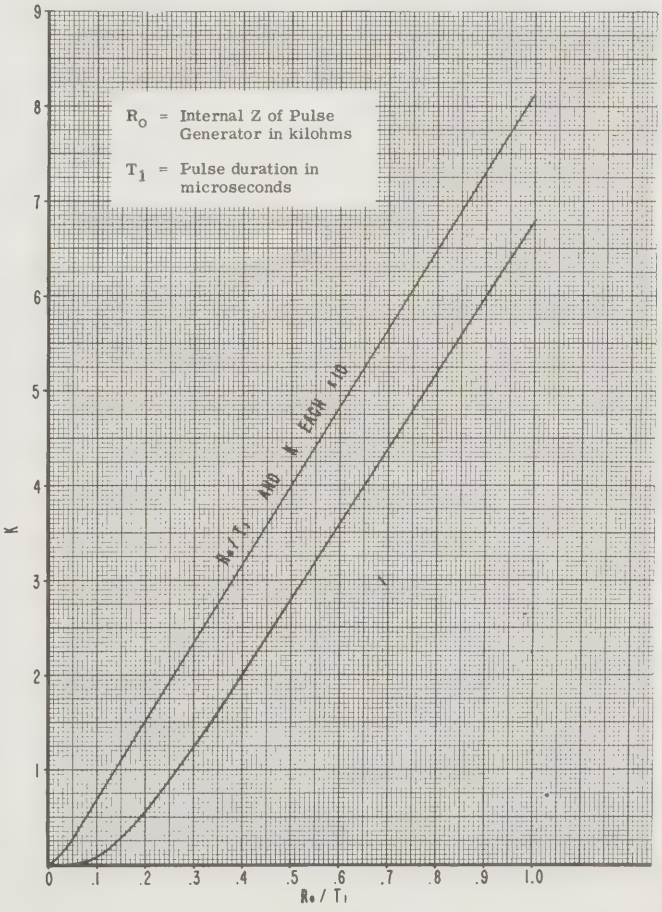


Figure 2-5. Graph used in Calculation of Pulse Voltages

2-10 RESISTANCE MEASUREMENT ABOVE 500 MEGOHMS

Because of its very high input resistance the Model 410B, supplemented by an external voltage, can be used to measure extremely high resistances. Any convenient d-c voltage up to 1000 volts may be used, the higher voltages permitting measurement of higher resistances. A 45-volt "B" battery extends the resistance measurement range to approximately 250,000 megohms. Resistances as high as several million megohms are easily and accurately made when the leakage between the test leads is held to a minimum by careful placement. The highest resistance that can be measured is limited by the total leakage between the DC test probe and the COMMON test probes on the voltmeter.

The measurement of extremely high resistance is accomplished by applying a known d-c voltage to the unknown resistance in series with the 410B as shown in Figure 2-6. The external voltage is first measured with the 410B and recorded. The positive side of the external voltage source is then connected through unknown resistance to the d-c measurement probe, the negative side of the voltage is connected to the COMMON lead from the 410B. The voltmeter range switch is then adjusted to obtain an upscale voltage reading. The meter indicates the voltage across the 122 megohm input resistance, which when multiplied by the ratio of the applied voltage to the measured voltage, minus one, gives the resistance of the unknown. The equation for determining an unknown resistance for any supply voltage and meter reading is given in the following equation. When the ratio of E applied to E measured is greater than 100:1, the minus one may be dropped with no practical loss in accuracy.

$$R_x = \left(\frac{E_{bb}}{E_m} - 1\right) R_m$$

E_{bb} = Externally applied battery or power supply voltage

E_m = Voltage read on d-c volts scale of voltmeter

R_m = Input resistance of voltmeter

(410A = 100 megohms)
(410B = 122 megohms)

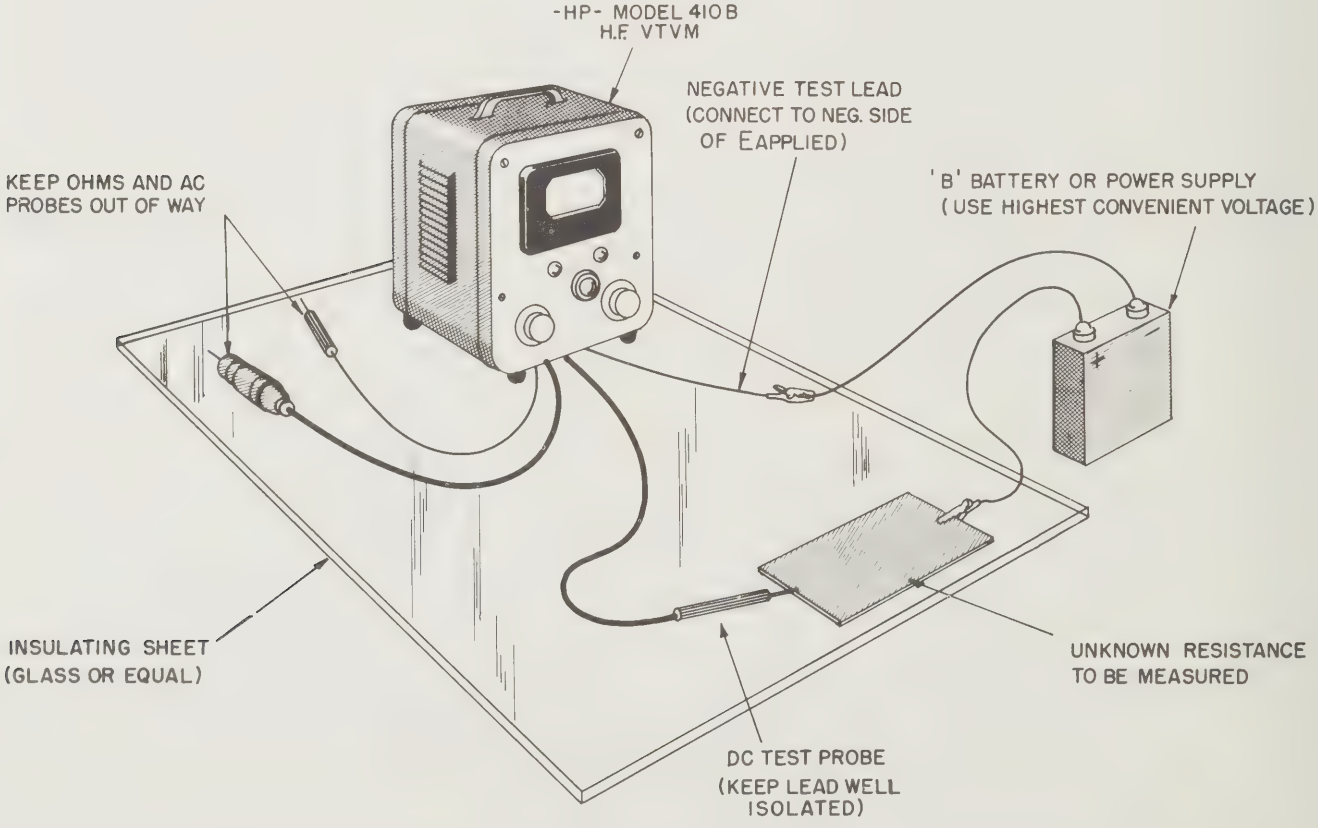


Figure 2-6. Setup for Measuring Extremely High Values of Resistance

SECTION III
THEORY OF OPERATION

3-1 GENERAL

The Ⓗ Model 410B is designed to measure the amplitude of a-c and d-c voltages and the values of resistances. To accomplish these measurements, the equipment's circuit is arranged as indicated by the block diagram of Figure 3-1. When measuring d-c voltages, the voltage to be measured is applied through a precision voltage divider to the input of a differential d-c amplifier. The output of the amplifier feeds a balanced bridge which has an indicating meter connected between the mid-points. The magnitude of deflection of the meter is thus proportional to the amplitude of the d-c voltage applied to the input of the differential amplifier.

When measuring a-c voltages, the voltage to be measured is converted to a d-c voltage in a special wide-band rectifier circuit. The output of the rectifier is then applied to the d-c voltage-measuring

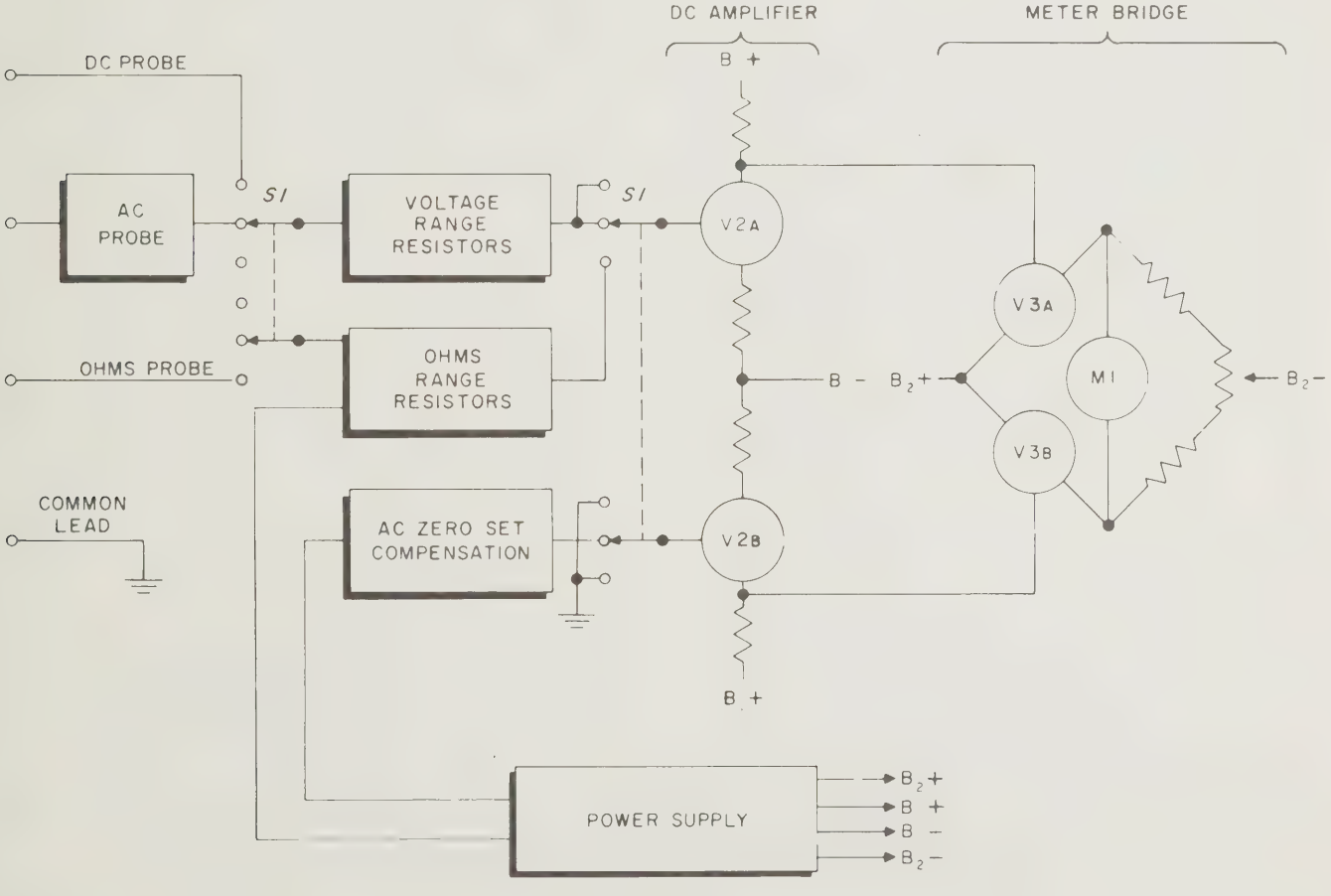


Figure 3-1. Block Diagram of Ⓗ Model 410B

circuit described above. A deflection of the indicating meter then occurs in proportion to the amplitude of the a-c voltage being measured.

For measuring resistance, a d-c voltage from the voltmeter power supply is applied through a large resistance to form a constant current source. This supplies a circuit consisting of the unknown resistance connected in parallel with a known resistance. The proportion of the internal voltage that appears across the unknown resistance is related to the ratio of the unknown to the known resistance. The voltage across the unknown resistance is then applied to the input of the differential amplifier as before, with the result that the magnitude of meter deflection is related to the value of the resistance being measured.

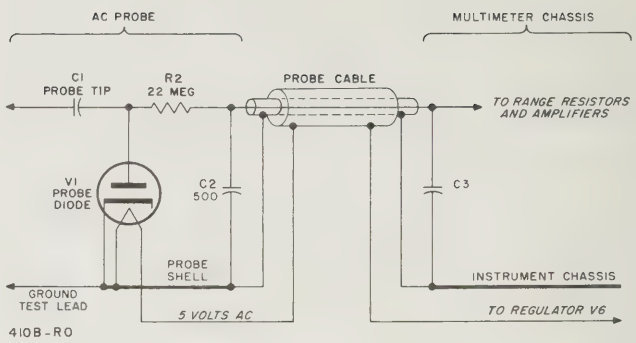


Figure 3-2. Schematic Diagram of AC Probe

3-2 R-F RECTIFIER

The circuit used for rectifying a-c signal voltages is shown in Figure 3-2. The circuit is a half-wave shunt-detector type circuit which operates to charge the small input coupling capacitor C1 to the peak value of the positive half of the a-c voltage being measured. To smooth the rectified a-c voltage for application to the differential amplifier, a large resistor (22 megohms) and capacitors C2 and C3 are connected across the output of the rectifier. The voltage across the capacitors rises to the peak value of the rectified wave and is applied through the precision voltage divider to the d-c amplifier.

Since the voltmeter is designed to be capable of measuring high frequencies, the rectifier circuit is built in the form of a probe so that it can be physically placed close to the point of measurement. The probe connects to the voltmeter proper through a flexible cable.

This arrangement permits short lead lengths for the actual a-c portion of the measuring circuit so that residual inductances will be minimized.

A cutaway view of the a-c probe showing the input blocking capacitor, rectifier diode, and RC filter is shown in Figure 3-3. The input capacitor is molded in a removable probe tip for applications where even the small lead length of the tip should be minimized. The diode is specially designed to have plane rather than circular geometry. This type of construction has been used in order to reduce the physical length of the diode and to achieve a diode having extremely low anode-cathode capacity. The construction is such that the probe has an input capacity of only about 1.5 mmf, about 1.3 of which is the anode-cathode capacity of the diode. To achieve short transit time for the diode, the anode-cathode spacing has been maintained at only .003 inch. Reliable r-f grounding of the diode cathode is obtained by use of a large area contact ring in the special socket for the diode. Figure 3-4 shows a line drawing of the probe diode.

The capacity in the RC filter is divided into two parts. A small 500 mmf capacitor, C2, is built into the probe near the base of the diode. At high frequencies this capacitor in combination with the 22-megohm filter resistor gives sufficient filtering so that the inductance of the flexible cable is of no consequence. For lower frequency filtering, Capacitor C3, is connected at the end of the cable inside the multimeter housing.



Figure 3-3. Cutaway View of High-Frequency Probe

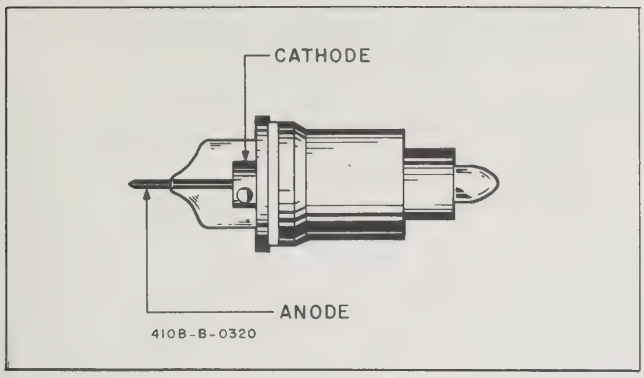


Figure 3-4. Actual Size Drawing of High-Frequency Diode

The probe is constructed from molded polystyrene to offer a low dielectric loss which, together with the low input capacity, makes the probe a high impedance device. The input impedance of the probe as a function of frequency is given in Figure 2-4.

The flexible cable connecting the probe to the voltmeter is a double-shielded single conductor cable. The outside shield carries a-c power for the diode heater; the inner lead carries the d-c voltage from the RC filter to the voltmeter. Ground return is made through the inner shield.

3-3 RANGE EXTENDING RESISTORS

To extend the voltage range over which both a-c and d-c measurements can be made, a precision voltage divider is connected to the input of the d-c amplifier. The taps on the divider are arranged so that the input to the amplifier does not exceed approximately .85 volt for a full-scale reading on d-c voltage measurements. On a-c measurements approximately 1.17 volts is applied to the amplifier for a full-scale reading. This increased voltage on a-c measurements is compensated by resistors in series with the indicating meter, as described later.

The precision voltage divider is made up of high-stability deposited carbon type resistors mounted on a seven-position rotary switch which serves as the range switch for the instrument.

3-4 DC AMPLIFIER

The taps on the precision voltage divider connect through the range switch to one input of the differential voltage amplifier. The amplifier consists of the two halves of a 12AU7 twin triode. The principle purpose of this amplifier is to serve as an impedance transformer between the 100-megohm impedance level in the range switch and the meter circuits. To achieve a high input impedance for the amplifier, it is operated without a grid resistor other than the 100-megohm voltage divider and at a low plate current in the order of a couple of microampers. Gas current effects in the high grid impedance are minimized by operating the amplifier tubes at a reduced heater voltage and a low plate voltage (approximately 20 volts). Very large cathode resistances are used to enhance the stability of the amplifier.

For a-c measurements the second or "balance" input to the differential amplifier is connected to a source of small d-c voltage in the power supply circuit. This arrangement is designed to compensate the voltmeter for "emission voltages" that occur in the probe diode. Because of the high thermal level of the probe diode cathode, electrons are emitted by the cathode even though no signal voltage is applied to the diode anode. Some of these electrons travel to the anode, giving it a net negative potential of approximately 1 volt, which will mask small signal voltages applied to the diode.

To compensate for this effect, the d-c voltage applied to the second input of the d-c amplifier is adjusted to be equal to the emission voltage of the diode. A voltage divider in the balance channel divides the compensating voltage in the same proportion as the input range switch divides the emission voltage so that the amplifier will always be compensated when the a-c probe is connected. The AC zero set control on the front panel adjusts the compensating voltage to exactly balance the voltage produced by the diode thereby bringing the meter to zero.

For d-c measurements the second input to the differential amplifier is grounded and serves only to supply a d-c level to balance the bridge.

3-5 METER CIRCUIT

The double-ended output of the differential amplifier is applied to a bridge circuit across which is connected the indicating meter, as illustrated by the diagram in Figure 3-5. Two arms of the bridge are triode tubes whose grids are connected to the two sides of the differential amplifier. With no voltage being measured, the two triodes have equal grid potentials and the bridge is in a balanced state. The front panel ZERO SET control R19a, a potentiometer located between the two legs of the bridge and the d-c supply voltage, establishes the exact electrical balance of the bridge for all types of operation. Potentiometer R32 is connected in series with the meter to adjust the sensitivity of the meter circuit to the precise required value.

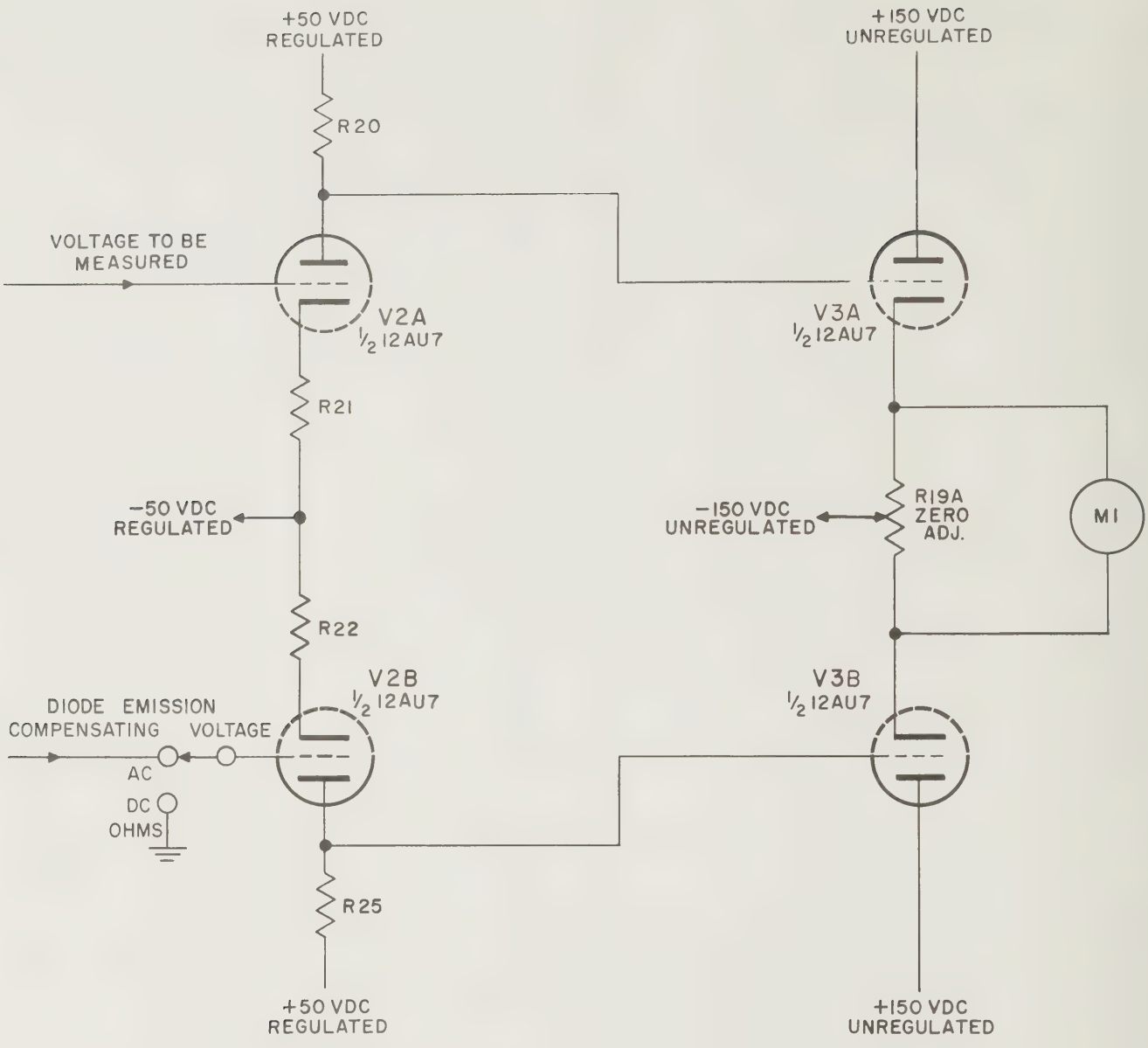


Figure 3-5. Basic DC Amplifier Circuit

To permit measurement of either positive or negative d-c voltages without reversal of the test leads the SELECTOR switch reverses the meter within the bridge so that an up-scale reading is obtained with either polarity.

For a-c measurements the range switch of the voltmeter connects in series with the meter additional current-reducing resistors (R35 through R40) to reduce the meter current by approximately 30% so that the same meter scale can be used for the a-c and d-c ranges. For the one and three volt a-c ranges, however, it is necessary to use special meter scales because the probe diode operation at low voltages is non-linear.

For resistance measurements the SELECTOR switch connects the meter in series with the front panel OHMS ADJ. ∞ control which adjusts the sensitivity of the meter to obtain a precise full-scale indication before making a measurement.

3-6 RESISTANCE MEASUREMENT

When the multimeter is to be used to measure resistance, the range switch connects an additional set of precision resistors to the input of the d-c amplifier as shown in the block diagram in Figure 3-1. A small, stable voltage of about 1.2 volts is taken from the regulated power supply and applied through a precision resistance to the input of the d-c amplifier thereby causing full-scale deflection of the meter. The resistance to be measured is then connected between the input of the d-c amplifier and ground. This resistance thus completes a voltage divider and reduces the voltage applied to the amplifier, bringing the meter reading down-scale. The range switch of the multimeter connects appropriate values of precision resistors into the ohmmeter circuit to extend the resistance-measuring range. (On the RX1 range the necessary voltage comes from a small selenium rectifier which is not regulated.)

3-7 POWER SUPPLY

The power supply circuit includes a full-wave rectifier with an RC filter at the output of the rectifier. An OB2 105-volt regulator tube provides regulated d-c voltage for operation of the differential d-c amplifier, ohmmeter circuits, and diode compensating circuits. D-c power for operating the bridge is obtained directly from the rectified output of the power supply. A regulated heater voltage of 5 volts a-c is also provided for the probe diode, regulation being obtained through the use of the constant current ballast tube V6. Potentiometer R50 shunting the diode heater is used to adjust the voltage across the heater to 5 volts. A small resistor is connected in series with the heater of V2 to operate this heater on approximately 4-1/2 volts. The heater winding also supplies a voltage which is rectified by a metallic rectifier for the RX1 resistance OHMS range only. This voltage is adjusted to approximately 1.2 volt by R49 to obtain full-scale deflection on the RX1 range consistent with that on the RX10 range, when the line voltage is at 115 volts.

The power transformer for the multimeter is equipped with two primary windings so that the instrument may be connected for operation on either 115 or 230 volt power. The windings are connected in parallel for use with 115 volts, and in series for 230 volts. For proper phasing of the windings the terminals on the transformer are numbered and wired as shown on the schematic diagram for the multimeter.

SECTION IV
MAINTENANCE

4-1 INTRODUCTORY

No routine maintenance procedures are required for the hp Model 410B. When replacing any of the tubes in the equipment, however, it is desirable to check the accuracy of the multimeter. To do this it is necessary to have a precision d-c voltmeter and a precision a-c voltmeter, preferably of the dynamometer type. The accuracy of these instruments should be within 1-2%, because the basic accuracy of the 410B is within 3%. The procedure to follow in checking and adjusting the calibration of the instrument are described in paragraphs 4-4 and 4-5.

If a tube failure occurs after an extended period of use such as 1000 hours of operating time, it is desirable to replace all tubes at that time, to avoid need for more frequent recalibration than necessary.

A trouble-shooting chart listing possible operating troubles is included at the end of this section (paragraph 4-7).

4-2 TUBE REPLACEMENT

REPLACING V1 -
When replacing probe diode V1, some change in a-c voltage-measuring accuracy may occur on the lower three a-c measuring ranges of the instrument. In a typical case these changes will be less than 2%. With some diodes the changes can be greater than this, however, so it is desirable to recheck calibration accuracy.

The quality of the individual replacement diode will also effect the high frequency accuracy of the instrument. However, specialized equipment is necessary for checking the high frequency accuracy. If high frequency errors are suspected with a new diode installed, it is recommended that another replacement diode be tried.

The heater voltage should be checked when probe diode V1 is replaced. Accurate setting of this voltage is necessary to insure proper operation and maximum life of the probe diode. To check the heater voltage of probe diode V1:

1) Remove back cover from the instrument by pushing down the button at the top rear of cabinet and slide the back cover off.

2) Remove two retaining screws from instrument rear and slide instrument chassis forward out of cabinet.

3) Connect 410B to variable power transformer, set line voltage to 115 volts (or 230 volts) and turn 410B on.

4) Connect an ac voltmeter such as hp Model 400D/H/L or Model 403A, between pin 7 or V6 (ballast tube and chassis ground. Adjust R50 to obtain 5.0 volts rms if the 201C diode is used and 6.3 volts rms if the EA53 diode is used.

REPLACEMENT OF V2 AND V3 -
When V2 or V3 are replaced, five checks should be made:

1. Amplifier balance with line voltage at 115 volts.
2. Microphonics: stability of the zero adjustment when the tubes are jarred.
3. Amplifier balance with line voltage change from 103 to 127 volts.
4. Gas in V2.
5. Voltage calibration.

NOTE

The following instructions describe a procedure which will provide optimum instrument performance over a wide range of line voltages. It is based on the procedure used at the factory. If such performance is not needed, the care in selection of tubes can be reduced considerably.

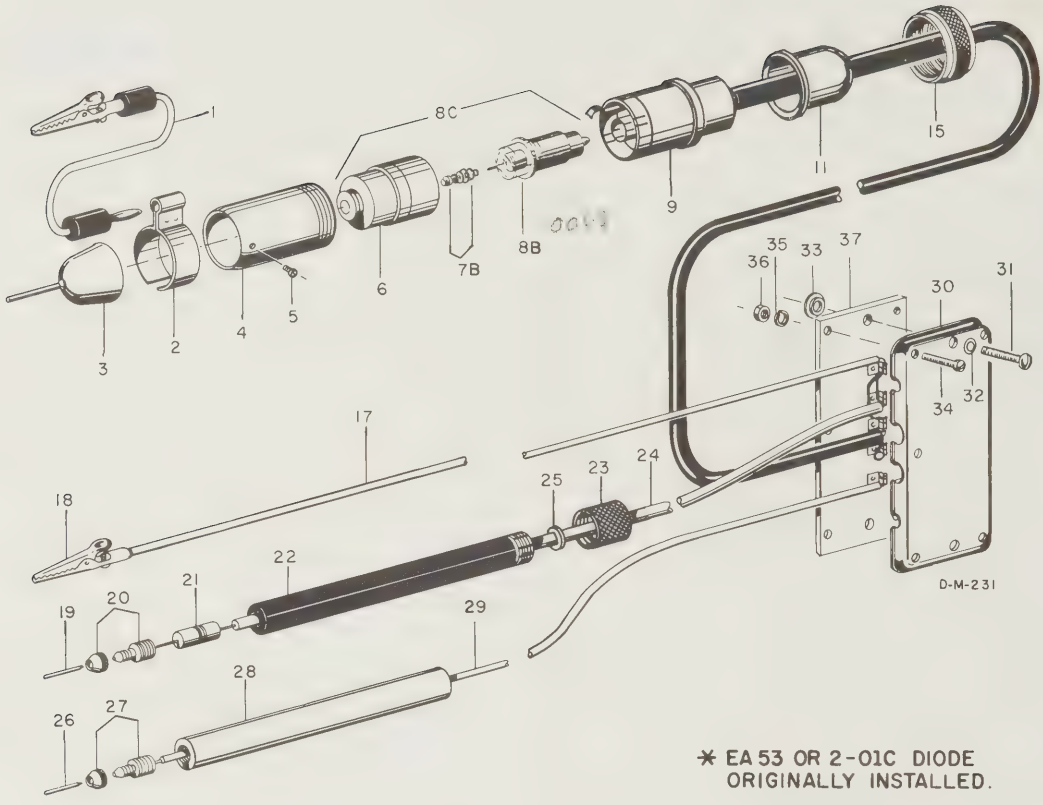


Figure 4-1. Test Probe Assembly, Including Exploded View of AC Probe

The following steps should be performed in the order given. If a tube fails to pass any test, it must be replaced and all tests repeated again in the proper order.

To obtain maximum range of adjustment of the ZERO SET control it is necessary that the four triode sections of the two 12AU7 tubes be similar in plate current characteristics. It is possible to have a combination of tubes which will have very little zero adjustment range on, say, (+) DC VOLTS and an excessive amount on (-) DC VOLTS. This is caused by non-uniformity between tubes. These characteristics also change considerably in the first 50 hours of tube operation.

A suggested method for determining if individual tubes are reasonably balanced is to first remove V2. With V3 only in its socket, check the ZERO ADJUST range on both (+) DC and (-) DC. Ideally, it should be the same in both positions of the FUNCTION switch. Select several tubes which are as nearly balanced as possible, by trying them in the V3 socket. Use the tube which has the best balance for V2 and the next best for V3. To insure the best margin of zero adjustment, the tubes should be selected to allow the ZERO ADJUST control to move the meter pointer at least 1/3 of the way up scale both with (+) and (-) DC VOLTS positions of the FUNCTION switch, when both tubes are in their sockets. Next, check for microphonics by first accurately setting the ZERO ADJUST to zero the meter and then tap V2 and V3. If the meter zero irratically changes position, one or both of the tubes have loose elements, which allow the static plate current to change value when jarred. Generally,

V2 is the most sensitive and should be suspected first. If the elements in V3 are very loose, it will cause the same indication. The defective tube or tubes should be replaced with ones which are of more sound construction. The balance test must be again repeated as described above.

To insure that the cathode emission is ample, the line voltage should be set to 115 volts. Allow the instrument to heat run for at least 5 minutes. Zero set the meter. Reduce the line voltage to 103 volts for a period of at least 1 minute. If the tubes have good cathode emission characteristics, the meter zero will not drift more than approximately 5%. If the zero drifts down scale to the left, the amount of drift can be measured from changing the position of the FUNCTION switch to the opposite polarity: (+) to (-) or vice versa, depending on the original position, so an up scale reading is obtained.

If the drift is not excessive, return the line voltage to 115 volts and reset the meter zero. After the tubes have stabilized at 115 volts, raise the line voltage to 127 volts and repeat the drift check. Again the drift should be less than 5%. If not, try another tube or tubes. V2 should be replaced first and then V3. All previous steps should be repeated first.

To check for a gassy V2, first accurately zero set the meter. Check the accuracy of the setting by switching the FUNCTION switch from (+) to (-) and back. If the setting is perfect, the meter pointer will not move. Feed in a d-c voltage of exactly 1.0 volt. (To facilitate this test the voltage should be fed through a dpdt switch so that the polarity can be quickly switched. If this is not done, it is very difficult to determine by eye if the two readings are the same within 1%).

If V2 is gassy, a certain error exists on the 1 volt range due to the gas current flowing through the 100 megohm resistive divider. Since the basic amplifier gain is set with the FUNCTION switch set to (+), this error is compensated for when the gain is set. When the polarity is reversed, however, the grid is biased negatively by the measured voltage and the value of the gas current changes somewhat. This results in a different reading.

A second method of checking for gas current is, to first accurately set the meter zero as described above. The RANGE SWITCH should be on the 1 VOLT DC range. Rotate the RANGE SWITCH to 300 VOLTS. If the input tube V2 is gassy, the zero will shift when the RANGE SWITCH is rotated. The grid impedance to ground is 100 megohms on the 1 VOLT range and approximately 300,000 ohms, on the 300 volt range (neglecting a fixed 5.6 megohm resistor). The effects of the gas current are thus reduced as the RANGE SWITCH is advanced to a higher range, which in turn causes the meter zero setting to change. NOTE: The effects of this test should not be confused with those of microphonic tubes. The Microphonic tube test must have been passed first.

Final voltage calibration should be made after tubes have been installed which pass all the above checks. Since the gain characteristics change somewhat during the first fifty hours of operation, it is desirable to heat run the instrument for at least this long before a final calibration is made. The calibration procedure to be followed after replacement of V2 or V3 is described in paragraph 4-4.

4-3 REPLACEMENT OF BALLAST TUBE V6

Failure of V6 is usually caused by overloading due to shorts. For this reason, before installing a new ballast tube, it is recommended that the resistance between pin 7 of V6 and ground be checked with V6 removed from socket. The resistance will initially read 2 to 3 ohms and slowly increase. If the reading does not increase to above 4 ohms, there may be a short. If the resistance increases to over 4 ohms, it is ordinarily safe to install the new ballast tube.

After installing the new ballast tube, measure the heater voltage of probe diode V1 (see para. 4-2).

4-4 BASIC VOLTAGE CALIBRATION

Before attempting to adjust either the a-c calibration accuracy or the ohmmeter calibration accuracy, it is necessary that the calibration of the d-c measuring circuits be accurate. Checking the d-c calibration accuracy is also recommended after replacing V2 or V3. The procedure is as follows:

a. Connect multimeter to a 115-volt power source and allow to heat for at least 15 minutes. It is desirable that the line voltage be accurately adjusted to 115 volts or to the predominating line voltage value if that value is somewhat less or more than 115 volts. The power transformer in the equipment is also designed to accommodate 230 volt lines; if the equipment is operated from 230 volt lines, the above information should be modified accordingly.

b. Remove the back cover from the instrument. To remove the cover push down the button at the top rear of the cabinet and slide back cover off.

c. Zero set the instrument with the RANGE switch set to the 1 volt range and the SELECTOR switch set to the + and - positions as described in paragraph 2-5.

d. Set SELECTOR switch to +. Range switch should remain at 1 volt.

e. Apply exactly 1 volt d-c to the d-c test leads. This 1 volt value can be obtained using a battery and potentiometer arrangement. The voltage applied to the voltmeter should be monitored and adjusted using the precision d-c meter described earlier. With exactly 1 volt applied to the multimeter the meter pointer should indicate an exact full-scale reading on the uppermost scale. If necessary, adjust R32 through the back of the instrument to make the meter read exactly full-scale. R32 is identified in Figure 4-2 and by appropriate markings on the back of the instrument.

f. The calibration of the remaining d-c ranges should now be checked insofar as the external precision meter and d-c source will permit. No adjustment circuits are provided, however, for the remaining d-c ranges. The accuracy of these ranges is determined by the values of the precision range switch resistors R3 through R9. A gross inaccuracy in any of the remaining d-c ranges indicates an incorrect range resistor or resistors.

g. Check a-c calibration accuracy as described below.

4-5 AC VOLTAGE CALIBRATION

The accuracy of the a-c voltage ranges of the multimeter should be checked after the probe diode V1 has been replaced. Before checking the a-c ranges, it is desirable to adjust the basic d-c voltage calibration as described above in paragraph 4-4. The procedure for checking and adjusting the a-c calibration is as follows:

a. Adjust line voltage as described in step a. of paragraph 4-4 above; remove back cover as described in step b. of the same paragraph.

b. Set SELECTOR switch to a-c and RANGE switch to 1 volt position. Allow equipment to heat for at least 15 minutes with these switch settings.

c. Set the FUNCTION switch to (+) DC and set the meter zero. Check by switching from (+) to (-) and back. There should be no shift. Set the FUNCTION switch to AC. Zero set a-c circuit with the AC ZERO control. (The RANGE switch still at the 1 volt position.)

d. Apply to the a-c probe a voltage of exactly 1 volt rms. This voltage should have an accurate, undistorted sine waveform. The frequency of this voltage should preferably be 100 cps or higher if permitted by the frequency characteristic of the dynamometer voltmeter. A good voltage source for this purpose is an accurate audio oscillator such as the ℗ Model 200AB, 205AG, etc. To determine that the voltage applied to the probe is accurate, it should be monitored by the precision dynamometer type voltmeter.

e. With exactly 1 volt rms applied to the probe, the voltmeter should indicate exactly full-scale on the 1 volt a-c (red) meter scale. If not, adjust R35 (available through back of instrument).

f. Set the RANGE selector to the 3-volt range. Increase voltage applied to probe to exactly 3 volts rms. Adjust potentiometer R39 to obtain accurate full-scale reading on the 3 volt a-c (red) meter scale.

g. Calibrate the remaining a-c ranges, reading the 1 and 3 volt d-c (black) scales of the meter. The following chart shows the adjusting potentiometers for each of the a-c ranges.

RANGE Switch Setting	Calibrating Voltage	Adjustment Resistor
1V	1V RMS	R35
3V	3V RMS	R39
10V	10V RMS	R40
30V	30V RMS	R36
100V	100V RMS	R37
300V	300V RMS	R38

4-6 OHMMETER ADJUSTMENTS

No internal adjustments are provided for the ohmmeter circuits other than for the full-scale setting of the RX1 range. The full-scale setting of the RX1 range may begin to differ from that of the other ranges as selenium rectifier CR1 ages. (Assuming the line voltage is the same value as when R49 was originally set.) To adjust the full-scale setting of the RX1 range to be equal to the full-scale setting of the other ranges, proceed as follows:

a. Connect multimeter to power line and allow to warm up. Normally the multimeter should be operated from 115 volts; however, if it is to be operated at line voltages substantially higher or lower than 115 volts the adjustment may be made at the expected line voltage.

b. Zero set the instrument as described in paragraph 2-3.

c. Set RANGE switch to RX10 range and adjust OHM ADJ. ∞ for exact full-scale meter reading.

d. Set RANGE switch to RX1 range.

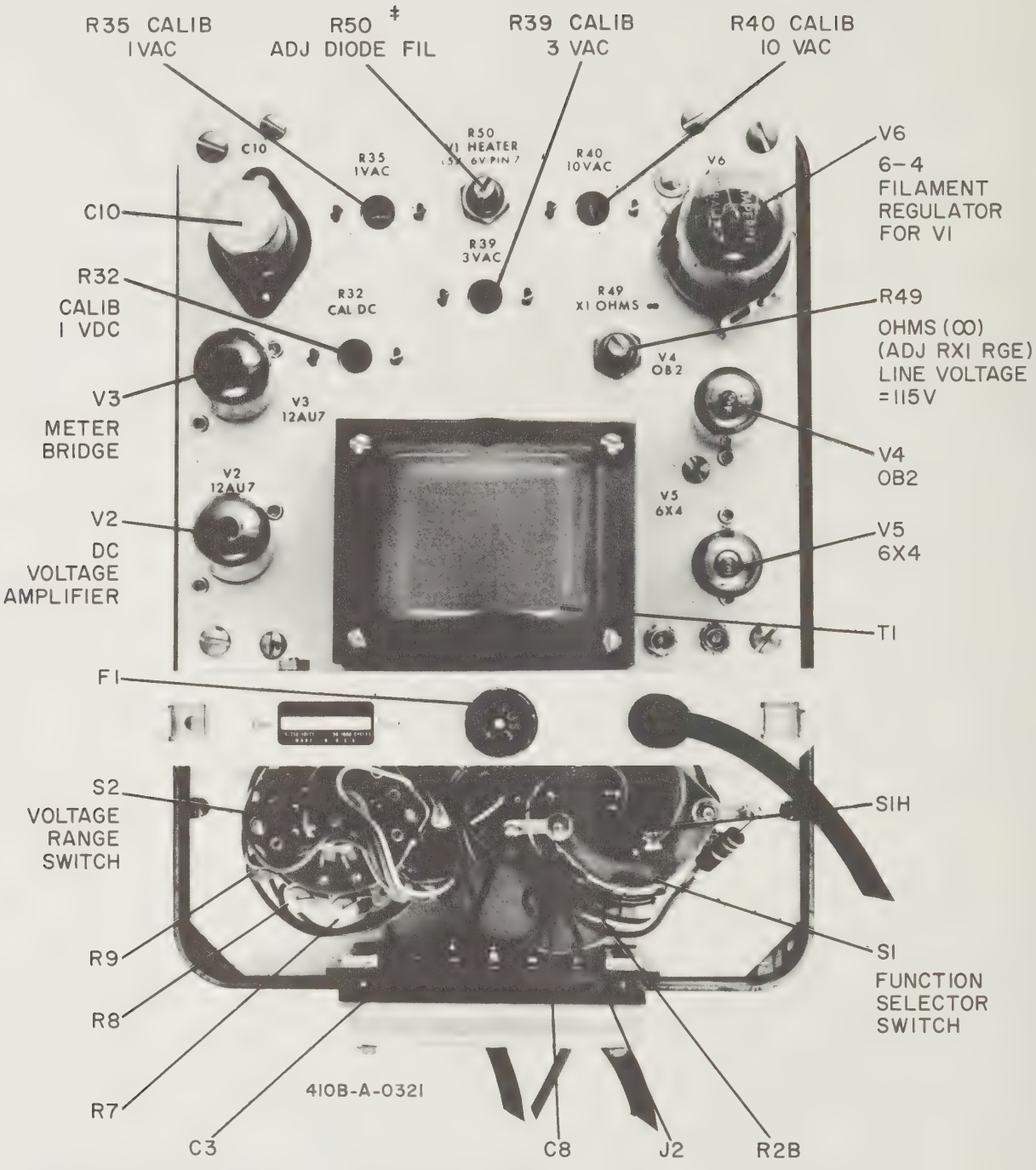
e. If meter pointer does not read exactly full-scale (∞), remove back panel from multimeter case and adjust R49 as necessary.

The accuracy of the RX1 range is not affected if the full-scale (∞) is not the same for RX1 and RX10 and above, since the OHMS ADJ. ∞ control should be adjusted to bring the pointer to (∞) before measurements are made.

4-7 TROUBLE SHOOTING CHART

Table 4-1. Trouble Shooting Chart

SYMPTOM	CAUSE OF TROUBLE	REMEDY AND CHECKS
AC power cord plugged in, instrument turned on, pilot light does not light and no readings obtained.	Defective power cord, plug, or receptacle. Fuse (F1) blown. Defective a-c Switch.	Check power source and connections. Check fuse (F1) and rectifier tube V5. Check power switch continuity.
No readings obtainable, no zero adjustment, pilot lamp lights.	Defective tubes V2, V3 or V5.	Check V2, V3, and V5, if necessary, replace and recalibrate, see paragraph 4-2.
Zero set drift or zero set not possible.	Defective tubes V2 and V3.	Check tubes V2 and V3, replace and recalibrate, see paragraph 4-2.
No a-c readings, d-c readings normal.	Probe cap loose, defective V1 or V6.	Tighten probe cap. Check V1 for operation.
A-c zero set drifts or inaccurate a-c readings only on all ranges.	Defective V1.	Replace V1 and recalibrate as instructed in paragraph 4-3.
A-c zero set not possible.	Outside shield of a-c probe cable shorted to ground.	Check cable and repair short.
Inaccurate d-c and a-c readings.	Defective V2 or V3, defective range resistor (R3 through R9), misadjustment of R32.	Check V2 and V3 or R3 through R9, readjust R32 as instructed in paragraph 4-4.
Erroneous resistance readings following use of OHMS probe on high d-c voltage.	Burned resistors R10 through R13.	Check resistors R10 through R13 and if necessary, replace burned resistor.



‡SET TO 5VAC RMS FOR 1920-0008 PROBE DIODE
6.3VAC RMS FOR 1920-0010 PROBE DIODE

Figure 4-2. Rear View of Model 410B Chassis Removed from Instrument Case

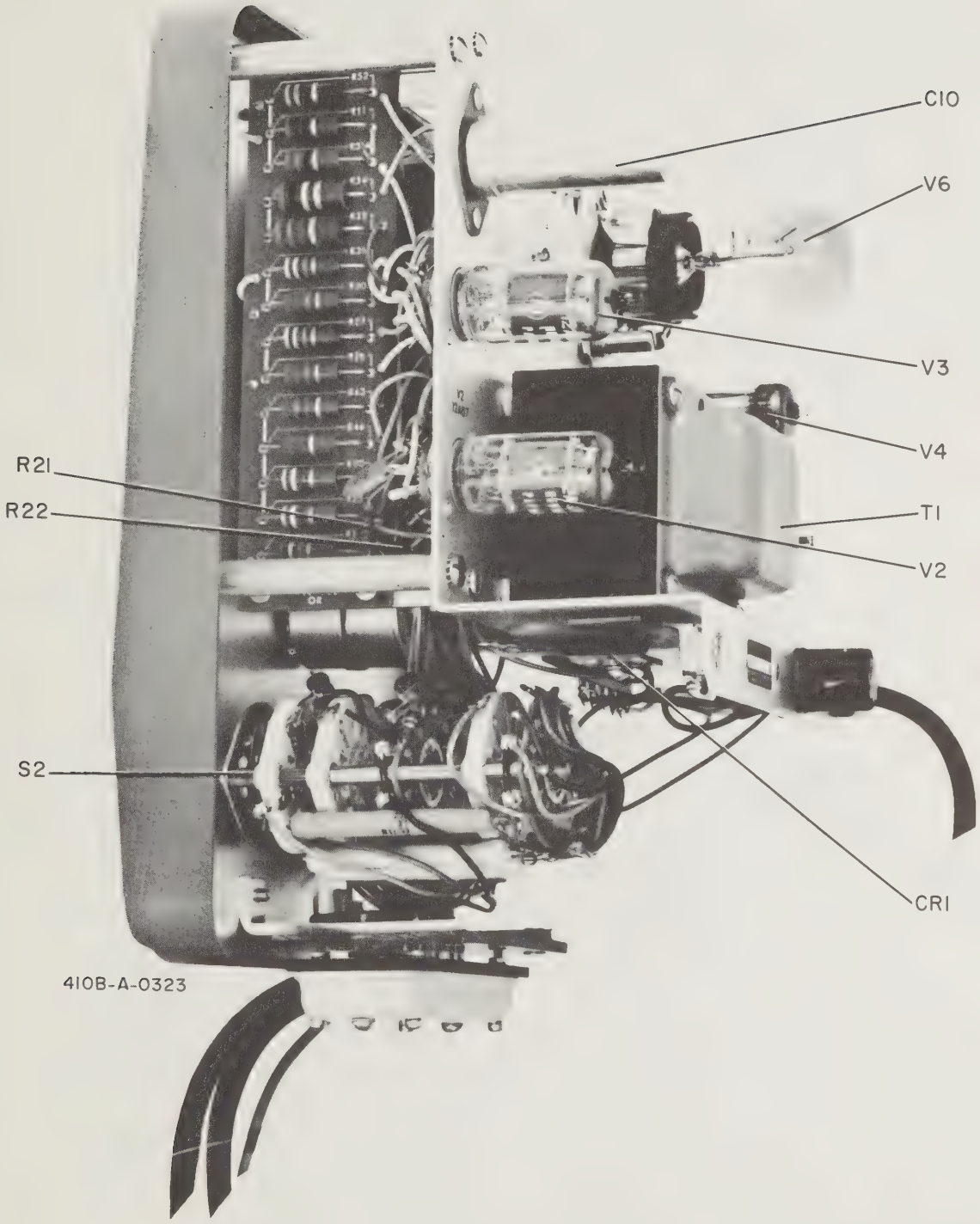


Figure 4-3. Right Side View of Model 410B

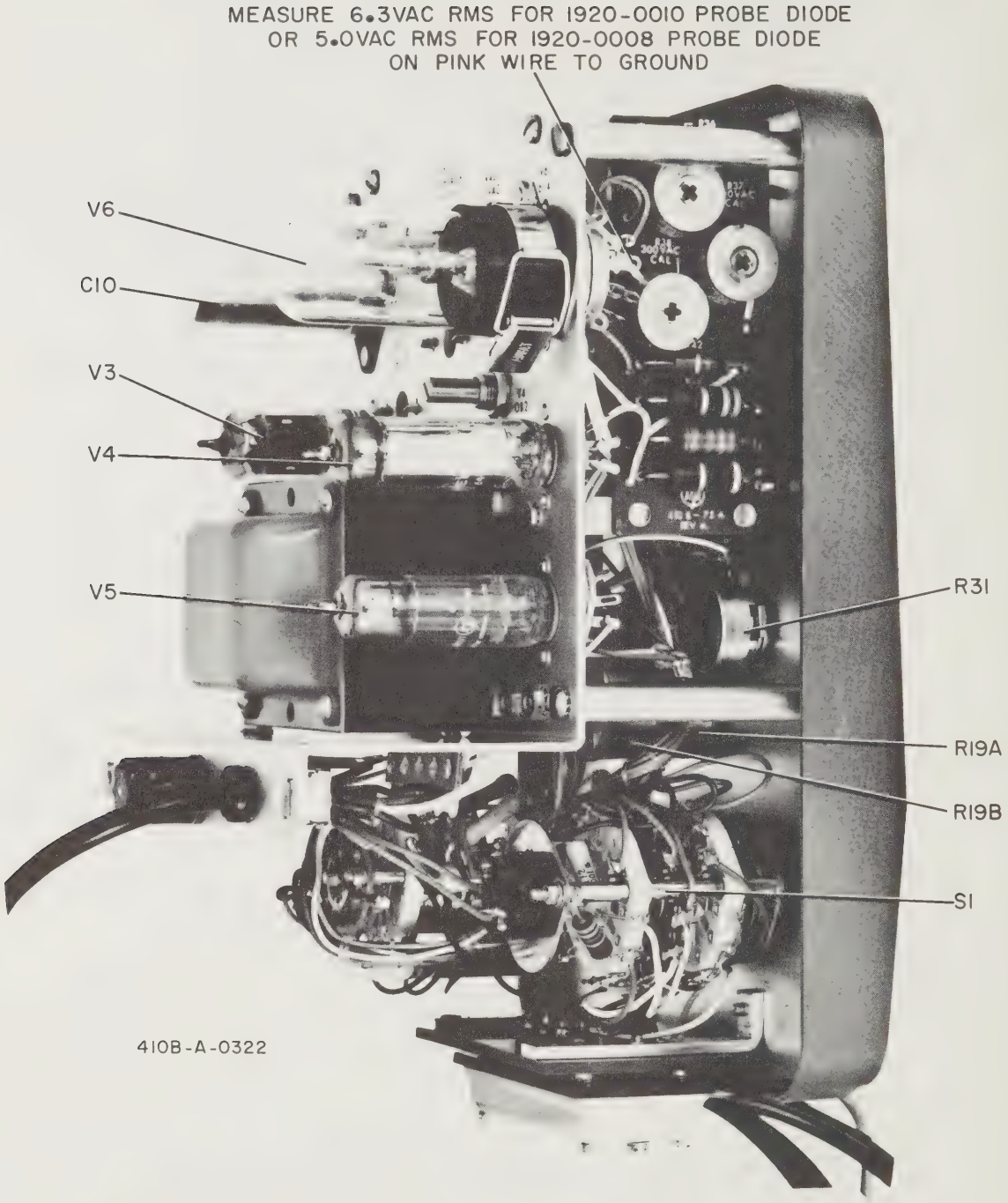


Figure 4-4. Left Side View of Model 410B

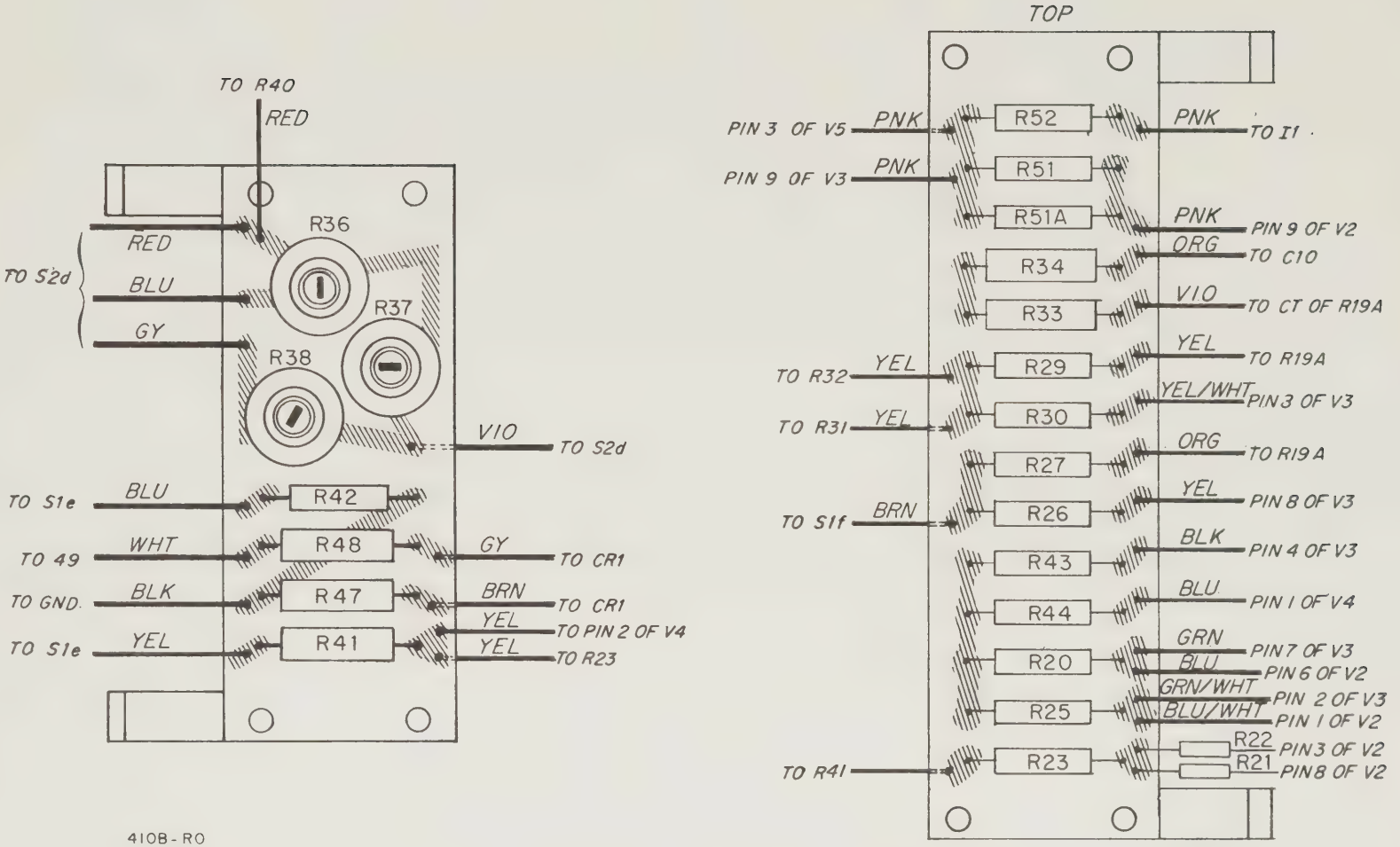


Figure 4-5. Resistor Board Details Model 410B

NOTES:

1. ALL CIRCUIT REFERENCES CORRESPOND TO THOSE IN THE SCHEMATIC WIRING DIAGRAM.
2. FRONT AND REAR SECTIONS OF SWITCH ARE VIEWED FROM THE BOTTOM OF THE INSTRUMENT AND THE KNOB END OF THE SWITCH. SWITCH SHOWN IN THE IV POSITION.

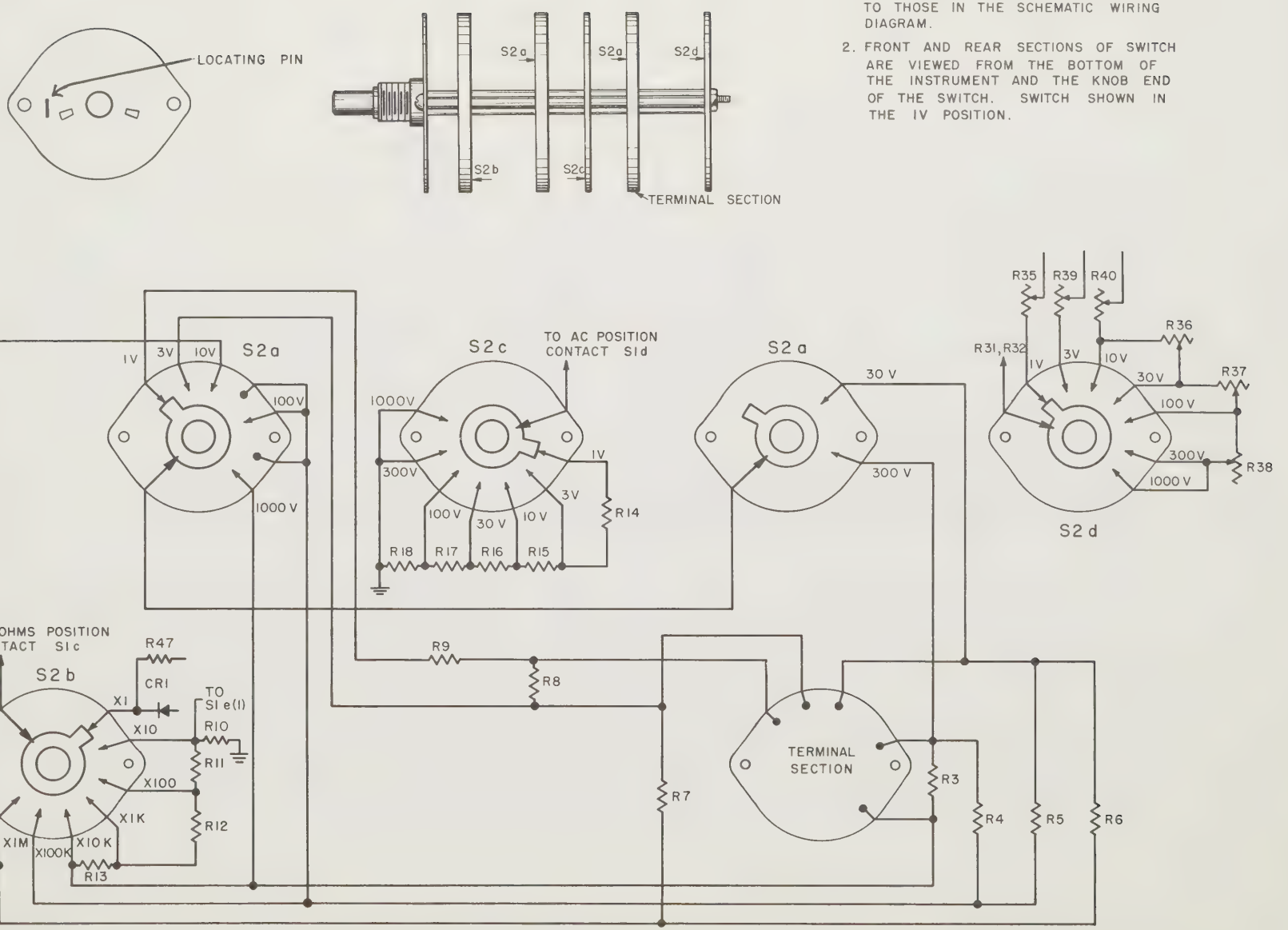


Figure 4-6. Range Switch Details Model 410B

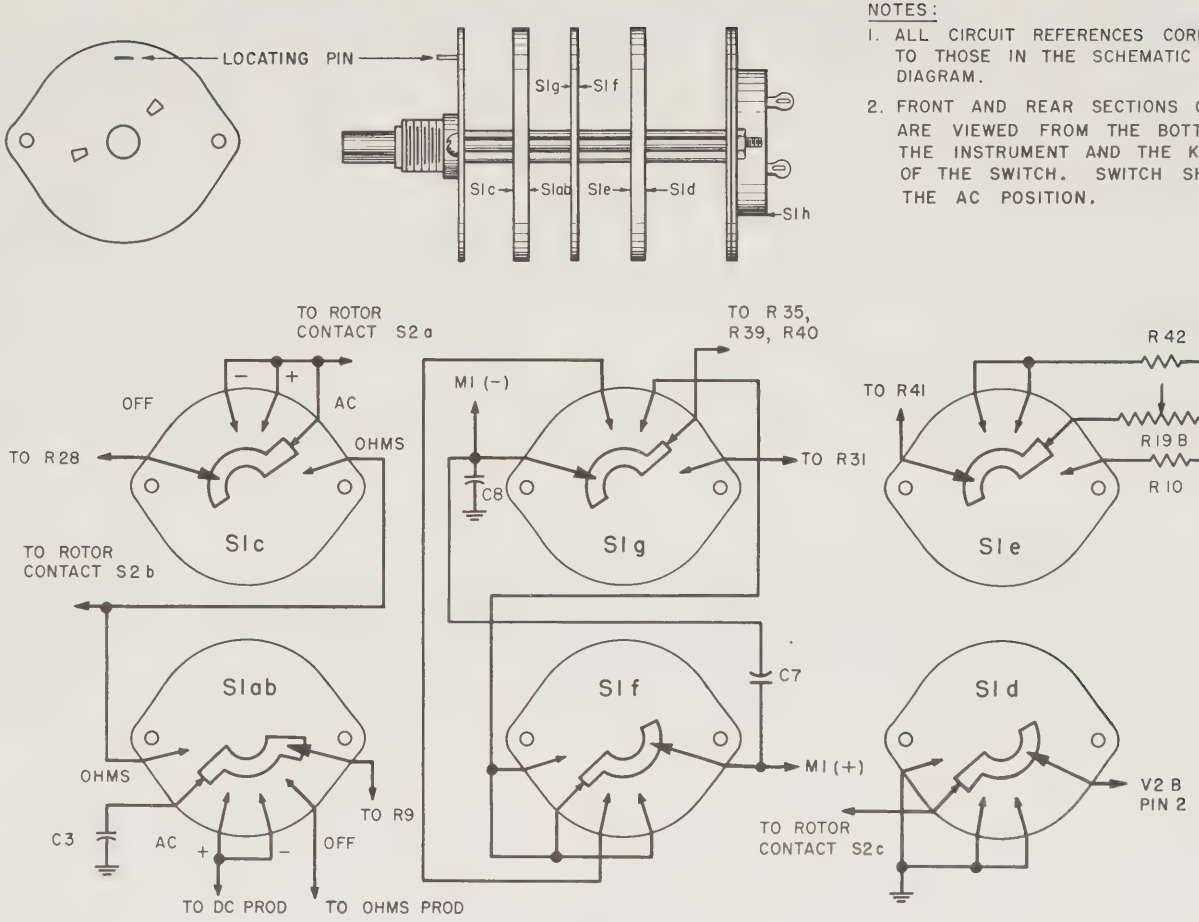


Figure 4-7. Selector Switch Details Model 410B

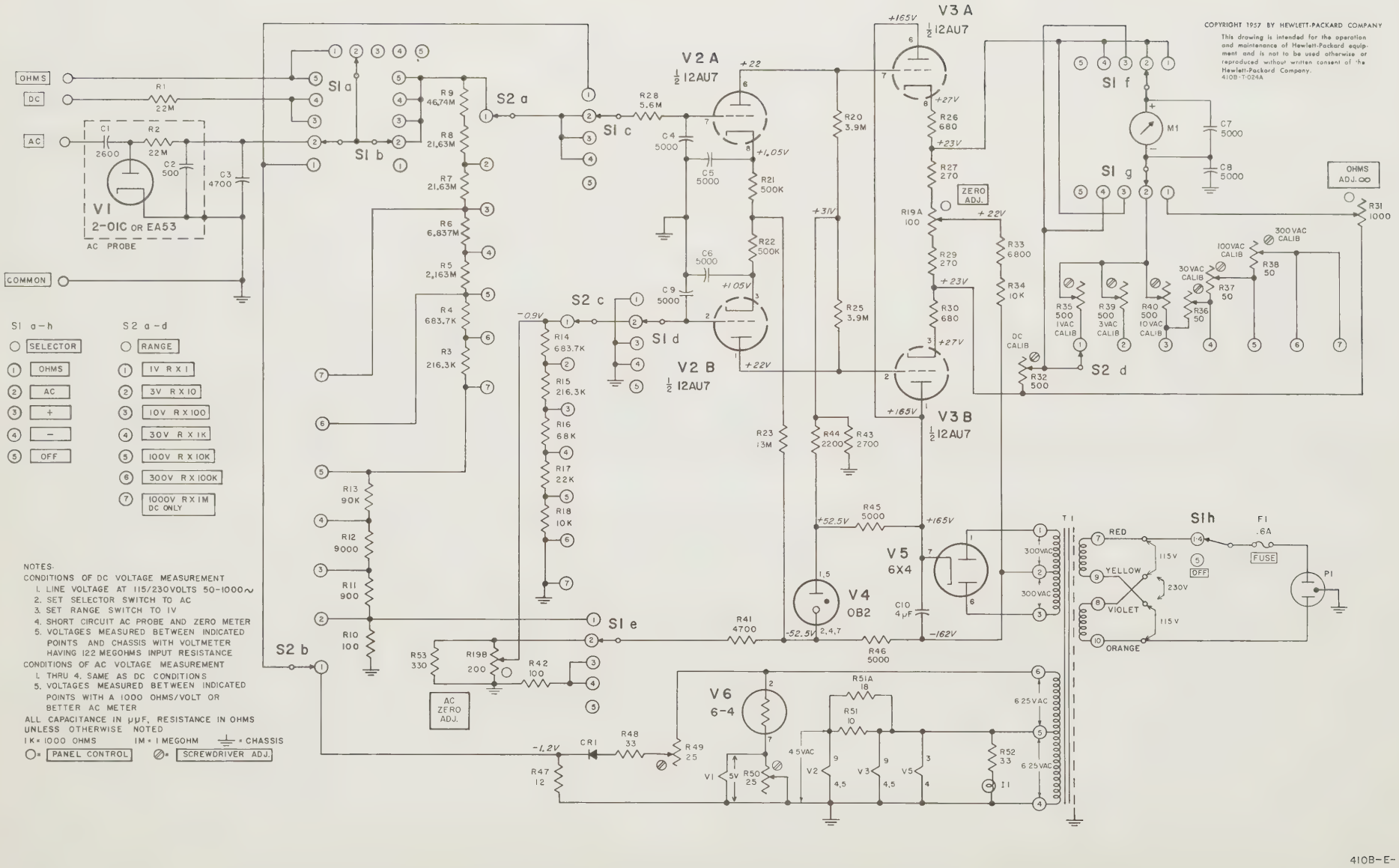


Figure 4-8 Schematic Diagram

SECTION V
REPLACEABLE PARTS

5-1. INTRODUCTION.

5-2. This section contains information for ordering replacement parts. Table 5-1 lists parts in alpha-numerical order of their reference designators and indicates the description and hp stock number of each part, together with any applicable notes. Table 5-2 lists parts in alpha-numerical order of their hp stock number and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code (see list of manufacturers in Appendix).

c. Manufacturer's part number.

d. Total quantity used in the instrument (TQ column).

5-3. Miscellaneous parts are listed at the end of Table 5-1.

5-4. ORDERING INFORMATION.

5-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard stock numbers.

5-6. NON-LISTED PARTS.

5-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

REFERENCE DESIGNATORS

A	= assembly	F	= fuse	P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
B	= motor	FL	= filter	Q	= transistor	W	= cable
C	= capacitor	J	= jack	R	= resistor	X	= socket
CR	= diode	K	= relay	RT	= thermistor	XF	= fuseholder
DL	= delay line	L	= inductor	S	= switch	XDS	= lampholder
DS	= device signaling (lamp)	M	= meter	T	= transformer	Z	= network
E	= misc electronic part	MP	= mechanical part				

ABBREVIATIONS

a	= amperes	elect	= electrolytic	mtg	= mounting	rot	= rotary
		encap	= encapsulated	my	= mylar	rms	= root-mean-square
bp	= bandpass					rmo	= rack mount only
bwo	= backward wave oscillator	f	= farads	NC	= normally closed	s-b	= slow-blow
		fxd	= fixed	Ne	= neon	Se	= selenium
c	= carbon			NO	= normally open	sect	= section(s)
cer	= ceramic	Ge	= germanium	NPO	= negative positive zero (zero temperature coefficient)	Si	= silicon
cmo	= cabinet mount only	grd	= ground (ed)			sil	= silver
coef	= coefficient	h	= henries			sl	= slide
com	= common	Hg	= mercury	nsr	= not separately replaceable	td	= time delay
comp	= composition					TiO_2	= titanium dioxide
conn	= connection	impg	= impregnated	obd	= order by description	tog	= toggle
crt	= cathode-ray tube	incd	= incandescent			tol	= tolerance
dep	= deposited	ins	= insulation (ed)	p	= peak	trim	= trimmer
EIA	= Tubes or transistors meeting Electronic Industries' Association standards will normally result in instrument operating within specifications; tubes and transistors selected for best performance will be supplied if ordered by hp stock numbers.	K	= kilo = 1000	pc	= printed circuit board	twt	= traveling wave tube
		lin	= linear taper	pf	= picofarads = 10^{-12} farads	var	= variable
		log	= logarithmic taper			w/	= with
		m	= milli = 10^{-3}	pp	= peak to peak	W	= watts
		M	= megohms	piv	= peak inverse voltage	ww	= wirewound
		ma	= milliamperes			w/o	= without
		μ	= micro = 10^{-6}	pos	= position (s)	*	= optimum value selected at factory, average value shown (part may be omitted)
		minat	= miniature	poly	= polystyrene		
		mfgl	= metal film on glass	pot	= potentiometer		
		mfr	= manufacturer	rect	= rectifier		

Table 5-1. Reference Designation Index

REFERENCE DESIGNATION	℗ STOCK NO.	DESCRIPTION	NOTE
C1 and C2		C: part of ac probe	
C3	0140-0017	C: fxd, mica, 4700 pf, ±10%	
C4 thru C9	0150-0014	C: fxd, cer, .005 μf, 500 vdcw	
C10	0180-0055	C: fxd, alum elect, 4 μf, 450 vdcw	
CR1	1880-0005	Rectifier: metallic	
F1	2110-0016	Fuse: cartridge: 0.6 amp, slow blow, for 115 v operation	
		Fuse: cartridge: 1/4 amp, slow blow, for 230 v operation	
I1	2140-0009	Lamp: incandescent: 6-8 v, .15 amp, #47	
M1	1120-0009	Meter	
P1	8120-0050	Power Cord	
R1	0690-2261	R: fxd, comp, 22 meg, ±10%, 1 w Part of Cable Ass'y, DC Probe	
R2		R: 22 meg, Part of ac probe, not separately replaceable	
R3	0730-0079	R: fxd, deposited carbon, 216.3 K, ±1%, 1 w	
R4	0730-0096	R: fxd, deposited carbon, 683.7 K, ±1%, 1 w	
R5	0730-0113	R: fxd, deposited carbon, 2.163 meg, ±1%, 1 w	
R6	0730-0130	R: fxd, deposited carbon, 6.837 meg, ±1%, 1 w	
R7 and R8	0733-0005	R: fxd, deposited carbon, 21.63 meg, ±1%, 1 w	
R9	0733-0011	R: fxd, deposited carbon, 46.74 meg, ±1%, 2 w	
R10	0727-0043	R: fxd, C flm, 100 ohms, ±1%, 1/2 w	
R11	0727-0095	R: fxd, C flm, 900 ohms, ±1%, 1/2 w	
R12	0727-0152	R: fxd, C flm, 9000 ohms, ±1%, 1/2 w	
R13	0727-0204	R: fxd, C flm, 90 K ohms, ±1%, 1/2 w	
R14	0727-0251	R: fxd, deposited carbon, 683,700 ohms, ±1%, 1/2 w	
R15	0727-0223	R: fxd, deposited carbon, 216,300 ohms, ±1%, 1/2 w	
R16	0687-6831	R: fxd, comp, 68 K ohms, ±10%, 1/2 w	
R17	0687-2231	R: fxd, comp, 22 K ohms, ±10%, 1/2 w	
R18	0687-1031	R: fxd, comp, 10 K ohms, ±10%, 1/2 w	
R19 A, B	2100-0050	R: var, ww, 2 sections, front: 100 ohms, rear: 200 ohms, ±10%, lin tap, 2 w	
R20	0689-3955	R: fxd, comp, 3.9 meg, ±5%, 1 w	
R21 and R22	0727-0244	R: fxd, C flm, 500 K ohms, ±1%, 1/2 w	
R23	0689-1365	R: fxd, comp, 13 meg, ±5%, 1 w	
R24		Not Assigned	
R25	0689-3955	R: fxd, comp, 3.9 meg, ±5%, 1 w	
R26	0689-6215	R: fxd, comp, 620 ohms, ±5%, 1 w	
R27	0689-3315	R: fxd, comp, 330 ohms, ±5%, 1 w	
R28	0687-5651	R: fxd, comp, 5.6 meg, ±10%, 1/2 w	
R29	0689-3315	R: fxd, comp, 330 ohms, ±5%, 1 w	
R30	0689-6215	R: fxd, comp, 620 ohms, ±5%, 1 w	

See introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	℗ STOCK NO.	DESCRIPTION	NOTE
R31	2100-0036	R: var, comp, lin tap, 1 K ohms, ±20%, 1/2 w	
R32	2100-0185	R: var, comp, lin tap, 500 ohms, ±30%, 1/4 w	
R33	0693-6821	R: fxd, comp, 6800 ohms, ±10%, 2 w	
R34	0693-1031	R: fxd, comp, 10 K ohms, ±10%, 2 w	
R35	2100-0185	R: var, comp, lin tap, 500 ohms, ±30%, 1/4 w	
R36, R37 and R38	2100-0206	R: var, ww, 50 ohms, ±10%, 1 w	
R39 and R40	2100-0185	R: var, comp, lin tap, 500 ohms, ±30%, 1/4 w	
R41	0693-4721	R: fxd, comp, 4700 ohms, ±10%, 2 w	
R42	0690-1011	R: fxd, comp, 100 ohms, ±10%, 1 w	
R43	0690-2721	R: fxd, comp, 2700 ohms, ±10%, 1 w	
R44	0690-2221	R: fxd, comp, 2200 ohms, ±10%, 1 w	
R45 and 46	0816-0006	R: fxd, ww, 5 K ohms, ±5%, 10 w	
R47	410B-26	R: fxd, ww, 12 ohms	
R48	0693-3301	R: fxd, comp, 33 ohms, ±10%, 2 w	
R49 and R50	2100-0876	R: var, ww, 25 ohms, ±10%, lin tap, 5 w	
R51	0690-1001	R: fxd, comp, 10 ohms, ±10%, 1 w optimum value selected at factory, average value shown	
R51A	0690-1801	R: fxd, comp, 18 ohms, ±10%, 1 w	
R52	0690-3301	R: fxd, comp, 33 ohms, ±10%, 1 w	
R53	0690-3311	R: fxd, comp, 330 ohms, ±10%, 1 w	
S1A thru	410B-19A	Selector Switch Assembly	
S1G	3100-0065	Switch: rotary, less components	
S1H	3130-0030	Switch: power, rear section of selector switch	
S2	410B-19W	Range Switch Assembly	
T1	9100-0021	Transformer: power	
V1	1920-0008	Tube: electron, 2-01C includes spring tip or Tube: electron, EA53 includes spring tip	
V2 and V3	5080-0681	Tube: electron, 12AU7	
V4	1940-0007	Tube: electron, OB2, voltage regulator	
V5	1930-0016	Tube: electron, 6 x 4, rectifier	
V6	0852-0003	Tube: ballast, #6-4, 6 w	
		MISCELLANEOUS	
	0370-0025	Knob: OHMS ADJ.	
	0370-0031	Knob: ZERO ADJ. Round	
	0370-0035	Knob: SELECTOR, RANGE	
	0370-0048	Knob: engraved AC	
	410B-76M	Connector Board: male	
	1400-0084	Holder, fuse:	
	1450-0003	Pilot lamp jewel	
	401B-21-95A	Assembly, Test lead, includes AC probe (less diode) DC probe, Ohms probe, Common Lead, female connector board and shield	
	410B-21-95B	Assembly, AC probe (less diode) with cable	
	410B-21-95C	Assembly, DC probe with cable	
	410B-21-95D	Assembly, Ohms probe with cable	
	410B-21-95E	Assembly, Common Lead	

See introduction to this section

Table 5-1. Reference Designation Index (Cont'd)

REFERENCE DESIGNATION	℔ STOCK NO.	DESCRIPTION	NOTE
(Figure 4-1)			
1	410B-21J	Jumper, ground, for AC probe	
2	410B-21H	Clip, ground, for AC probe	
3	410B-21D	Probe head	
4	410B-21E	Sleeve, for AC probe	
5	2220-0001	Screw, machine, Fillister Head, No. 4-40 x 3/16 in.	
6	410B-21C	Assembly, probe contact, for AC probe	
7A	410B-21N	Tip and contact spring (for 2-10C diode)	
7B	410B-21P	Tip and spring (for EA53 diode)	
8A,8B		Tube, electron (see VI)	
8C	00410-69501	Includes 6, 7B, 8B (Figure 4-1)	
9	410B-21B	Assembly, socket w/cable for probe diode	
11	410B-21B-5	Cap	
15	410B-21F	Ring, retaining (AC probe)	
17	8150-1038	Cable, blk, 42 in.	
18	1400-0046	Clip, alligator	
19	1490-0013	Needle, phono	
21		Resistor: fxd, comp (See R1)	
22	410B-21L	Body, DC probe	
23	410B-21K	Nut, DC probe	
24	8120-0004	Cable, coaxial, 41 in.	
25	0900-0013	"O" Ring	
26	1490-0013	Needle, phono	
27	1490-0010	Chuck with Nut and Needle	
26, 27, 28	410B-21-95G	Body, Ohms probe with Chuck/Nut and Needle	
29	8150-0139	Cable, red, 42 in.	
30	410B-55	Shield, test lead terminal board	
31	2360-0015	Screw, machine, round head, No. 6-32 x 1 - 1/8 in.	
32	3050-0016	Washer, flat, fiber No. 6	
33	3050-0005	Washer, fiber, extruder No. 6	
34	2220-0006	Screw, machine, Fillister head, No. 4-40 x 3/4 in.	
35	2190-0030	Washer, lock, No. 4, 1/16 in.	
36	2340-0001	Nut, No. 4 - 40 x 3/16 in.	
37	410B-76F	Connector, female board	

See introduction to this section

Table 5-2. Replaceable Parts

STOCK NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
0140-0017	C: fxd, mica, 4700 pf, ±10%	14655	RCM30E472K	1	
0150-0014	C: fxd, cer, .005 μf, 500 vdcw	96095	D1-4	6	
0180-0055	C: fxd, alum elect, 4μf, 450 vdcw	56289	D32478	1	
0370-0025	Knob: OHMS ADJ.	28480	5040-0058	1	
0370-0031	Knob: ZERO ADJ., round	28480	0370-0031	1	
0370-0035	Knob: SELECTOR, RANGE	28480	0370-0035	2	
0370-0048	Knob: engraved AC, round	28480	0370-0048	1	
410B-19A	Selector Switch Ass'y (interchangeable with 410B-19B)	28480	401B-19A	1	
410B-19W	Range Switch Ass'y	28480	410B-19W	1	
410B-21B	Ass'y, socket w/cable for probe diode	28480	410B-21B	1	
410B-21C	Ass'y, probe contact for ac probe	28480	410B-21C	1	
410B-21D	Probe head	28480	410B-21D	1	
410B-21E	Sleeve for ac probe	28480	410B-21E	1	
410B-21F	Ring, retaining (ac probe)	28480	410B-21F	1	
410B-21H	Clip, ground, for ac probe	28480	410B-21H	1	
410B-21J	Jumper, ground, for ac probe	28480	410B-21J	1	
410B-21K	Nut, dc probe	28480	410B-21K	1	
410B-21L	Body, dc probe	28480	410B-21L	1	
410B-21N	Tip and contact spring (for 2-01C diode)	28480	410B-21N	1	
410B-21P	Tip and contact spring (for EA53 diode)	28480	410B-21P	1	
00410-69501	Diode Replacement Kit Contains 6, 7B and 8B	28480	00410-69501	1	
410B-21-95A	Ass'y, test lead, includes ac probe (less diode) dc probe, ohms probe, common lead, female connector board and shield. (interchangeable w/ 410B-21-95B)	28480	410B-21-95A		
410B-21-95B	Ass'y, ac probe (less diode) with cable	28480	410B-21-95B		
410B-21-95C	Ass'y, dc probe with cable	28480	410B-21-95C		
410B-21-95D	Ass'y, ohms probe with cable	28480	410B-21-95D		
410B-21-95E	Ass'y, common lead	28480	410B-21-95E		
410B-26	R: fxd, ww, 12 ohms	28480	410B-26	1	
410B-55	Shield, test lead terminal board	28480	410B-55		
410B-76F	Connector, female board	28480	410B-76F		
410B-76M	Connector board, male	28480	410B-76M		
0687-1031	R: fxd, comp, 10 K ohm, ±10%, 1/2 w	01121	EB-1031	1	
0687-2231	R: fxd, comp, 22 K ohm, ±10%, 1/2 w	01121	EB-2231	1	
0687-5651	R: fxd, comp, 5.6 meg, ±10%, 1/2 w	01121	EB-5651	1	
0687-6831	R: fxd, comp, 68 K ohms, ±10%, 1/2 w	01121	EB-6831	1	
0689-1365	R: fxd, comp, 13 meg, ±5%, 1 w	01121	GB-1365	1	
0689-3315	R: fxd, comp, 330 ohms, ±5%, 1 w	01121	GB-3315	2	
0689-3955	R: fxd, comp, 3.9 meg, ±5%, 1 w	01121	GB-3955	2	
0689-6215	R: fxd, comp, 620 ohms, ±5%, 1 w	01121	GB-6215	2	
0690-1001	R: fxd, comp, 10 ohms, ±10%, 1 w Optimum value selected at factory, Average value shown	01121	GB-1001	1	
0690-1011	R: fxd, comp, 100 ohms, ±10%, 1 w	01121	GB-1011	1	
0690-1801	R: fxd, comp, 18 ohms, ±10%, 1 w	01121	GB-1801	1	
0690-2221	R: fxd, comp, 2200 ohms, ±10%, 1 w	01121	GB-2221	1	
0690-2261	R: fxd, comp, 22 meg, ±10%, 1 w	01121	GB-2261	2	
0690-2721	R: fxd, comp, 2700 ohms, ±10%, 1 w	01121	GB-2721	1	
0690-3311	R: fxd, comp, 330 ohms, ±10%, 1 w	01121	GB-3311	1	

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

℗ STOCK NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
0693-3301	R: fxd, comp, 10 K ohm, ±10%, 2 w	01121	HB-1031	1	
0693-3301	R: fxd, comp, 33 ohms, ±10%, 2 w	01121	HB-3301	1	
0693-4721	R: fxd, comp, 4700 ohms, ±10%, 2 w	01121	HB-4721	1	
0693-6821	R: fxd, comp, 6800 ohms, ±10%, 2 w	72758	HB-6821	1	
0727-0043	R: fxd, C flm, 100 ohms, ±10%, 1/2 w	94459	CVG	1	
0727-0152	R: fxd, C flm, 9000 ohms, ±1%, 1/2 w	91637	MCS 1/2	1	
0727-0204	R: fxd, C flm, 90 K ohm, ±1%, 1/2 w	91637	MCS 1/2	1	
0727-0223	R: fxd, depc, 216,300 ohms, ±1%, 1/2 w	91637	MCS 1/2	1	
0727-0244	R: fxd, C flm, 500 K ohm, ±1%, 1/2 2	91637	DCS 1/2	2	
0727-0251	R: fxd, depc, 683,700 ohm, ±1%, 1/2 2	91637	MCS 1/2	1	
0727-0095	R: fxd, C flm, 900 ohm, ±1%, 1/2 2	94459	CVS	1	
0730-0079	R: fxd, depc, 216.3 K, ±1%, 1 w	91637	DC-1	1	
0730-0096	R: fxd, depc, 683.7 K, ±1%, 1 w	91637	DC-1	1	
0730-0113	R: fxd, depc, 2.163 meg, ±1%, 1w, 500 vdcw	91637	DC-1	1	
0730-0130	R: fxd, depc, 6.837 meg, ±1%, 1 w	91637	DC-1	1	
0733-0005	R: fxd, depc, 21.63 meg, ±1%, 2 w	91637	DC-2	2	
0733-0011	R: fxd, depc, 46.74 meg, ±1%, 2 w	91637	DC-2	1	
0816-0006	R: fxd, ww, 5 K, ±5%, 10 w	35434	obd#	2	
0852-0003	Tube, ballast: #6-4, 6 w	000WW	MEC-6-4	1	
0900-0013	"O" Ring	28480	0900-0013	1	
1102-0009	Meter	55026	Model 121	1	
1400-0046	Clip, alligator	28480	1400-0046		
1400-0084	Holder, fuse	75915	342014	1	
1450-0003	Pilot lamp jewel	72619	81-121	1	
1490-0010	Body, Ohms probe	28480	1490-0011		
1490-0013	Needle, phono	28480	1490-0013		
1880-0005	Rectifier, metallic	84970	4SF-1H1-RV	1	
1920-0008	Tube, electron, 2-01C includes tip	72092	#2-01C	1	
1920-0010	Tube, electron, EA53 includes spring tip	73445	EA53	1	
1930-0016	Tube, electron, 6x4, rectifier	16758	obd#	1	
1940-0007	Tube, electron, OB2, voltage regulator	86684	1332	1	
2100-0036	R: var, comp, lin tap, 1 K, ±20%, 1/2 w	71450	Series 45	1	
2100-0050	R: var, ww, 2 sections, front: 100 ohms, rear: 200 ohms, ±10%, lin tap, 2 w	71450	C2-252	1	
2100-0185	R: var, comp, lin tap, 500 ohms, ±30%, 1/4 w	11237	Type PM45	4	
2100-0206	R: var, ww, 50 ohms, ±10%, 1 w	79727	E-870	3	
2100-0870	R: var, ww, 25 ohms, ±10%, lin tap, 5 w	71450	Series AW	2	
2110-0016	Fuse, cartridge: 0.6 amp, slow blow, for 115 v operation	24446	313.600	1	
2110-0018	Fuse, cartridge: 1/4 amp, slow blow, for 230 v operation	24446	obd#	1	
2140-0009	Lamp, incandescent: 6-8 v, .15 amp, #47	24455	#47	1	
2190-0030	Washer, lock, No. 4, 1/16 in.	28480	2190-0030		
2220-0001	Screw, machine, fillister head, No. 4-40 x 3/16 in.	28480	2220-0001		
2220-0006	Screw, machine, fillister head, No. 4-40 x 3.4 in.	28480	2220-0006		
2340-0001	Nut, No. 4-40 x 1/16 in.	28480	2340-0001		
2360-0015	Screw, machine, round head, No. 6-32 x 1-1/8 in.	28480	2360-0015		

See introduction to this section

Table 5-2. Replaceable Parts (Cont'd)

STOCK NO.	DESCRIPTION	MFR	MFR PART NO.	TQ	
3050-0005	Washer, fiber, extruder #6	28480	3050-0005	1	
3050-0065	Washer, flat, fiber No. 6	28480	3050-0023	1	
3100-0065	Switch, rotary: less components	28480	3100-0065	1	
3130-0030	Switch, power: rear section of selector switch	76854	135664-L2	1	
5080-0681	Tube, electron: 12AU7	28480	12AU7	2	
8120-0003	Cable, coaxial, 41 in.	28480	8120-0004	1	
8120-0050	Power cord	70903	KH4096	1	
8150-0138	Cable, black, 42 in.	28480	8150-0138	1	
8150-0139	Cable, red, 42 in.	28480	8150-0139	1	
9100-0021	Transformer, power	28480	4076	1	

See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N. Y.
00334	Humidail Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Morristown, N.J.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N. J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04298	Elgin National Watch Co., Electronics Division	Burbank, Calif.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Prods., Inc. Electronic Tube Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc., Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
04796	Sequoia Wire & Cable Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P. M. Motor Company	Chicago 44, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metropolitan Telecommunications Corp., Metro Cap. Division	Brooklyn, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Devices, Inc.	Inglewood, Calif.
06540	Amatom Electronic Hardware Co. Inc.	New Rochelle, N. Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06751	U. S. Semcor Division of Nuclear Corp. of America	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N. Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	The Birtcher Corp.	Los Angeles, Calif.
07700	Technical Wire Products	Springfield, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert, Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada.
08717	Sloan Company	Burbank, Calif.
08718	Cannon Electric Co., Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S., Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays, Inc.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
09664	The Bristol Co.	Waterbury, Conn.
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronic, Inc.	Santa Ana, Calif.
11711	General Instrument Corporation Semiconductor Division	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N. J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
13103	Thermolloy	Dallas, Texas
13396	Telefunken (G.M.B.H.)	Hannover, Germany
13835	Midland Mfg. Co.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co. Inc.	Brooklyn, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15909	The Daven Co.	Livingston, N.J.
16037	Spruce Pine Mica Co.	Spruce Pine, N. C.
16352	Computer Diode Corp.	Lodi, N. J.
16688	De Jur-Amsco Corporation	Long Island City 1, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Ind.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21226	Executive, Inc.	New York, N.Y.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G.E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Corp.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Company	Lexington, Mass.
52090	Rowan Controller Co.	Baltimore, Md.
63743	Ward Leonard Electric	Mt. Vernon, N.Y.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth 1, N.J.
60741	Tripplett Electrical Inc.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Swissvale, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66295	Wittek Manufacturing Co.	Chicago 23, Ill.
66346	Wollensak Optical Co.	Rochester, N.Y.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70319	Allmetal Screw Prod. Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp.	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72092	Eitel-McCullough, Inc.	San Bruno, Calif.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
71707	Coto Coil Co., Inc.	Providence, R.I.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72699	General Instrument Corp., Semiconductor Div.	Newark, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co, Inc.	Hicksville, N.Y.
73490	Beckman Helipot Corp.	So. Pasadena, Calif.
73506	Bradley Semiconductor Corp.	Hamden, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73734	Federal Screw Prod. Co.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N. Y.
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Pacific Division of Bendix Corp.	No. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phaostran Instrument and Electronic Co.	South Pasadena, Calif.
77250	Phoell Mfg. Co.	Chicago, Ill.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	Potter and Brumfield, Div. of American Machine and Foundry	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products	Elizabeth, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association. Any brand tube meeting EIA standards	Washington, D.C.
80207	Unimax Switch, Div. of W.L. Maxson Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Laboratories, Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Fulton Controls Co.	Columbus 16, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Electronics Co., Inc.	Norwalk, Conn.

Galley 3 – Hewlett Packard Code List

From: FSC. Handbook Supplements
H4-1 Dated DECEMBER 1964
H4-2 Dated MARCH 1962

MANUAL CHANGES

MODEL 410B Vacuum Tube Voltmeter

Manual Serial Prefixed: 024-

HP Part No. 410B-901

Instrument Serial Number	Make Manual Changes	Instrument Serial Number	Make Manual Changes
All	Errata		

HP Part No. and HP Stock No. are synonymous

Errata

Paragraph 2-8, step c (third sentence from last)
Change -hp- Model 455A to -hp- Model 11042A

Figure 4-1
Add Note: Part numbers are listed under the Miscellaneous portion of Table 5-1

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

Code No.	Manufacturer	Address
81349	Military Specification	
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Components Div., Industr. Tube Operations	Newton, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81541	The Airpax Products Co.	Cambridge, Mass.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs, Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Div. of Texas Instruments, Inc., Spencer Prods.	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Manufacturing Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfr. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	Pyramid Electric Co.	Darlington, S.C.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Battery	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronis, Inc.	New York, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
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000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
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Appendix C

MANUAL BACKDATING CHANGES

MODEL 410B

VACUUM TUBE VOLTMETER

Manual Serial Prefixed 024
-hp- Part No. 410B-901

To adapt this manual to instruments with other serial prefixes check for errata below, and make changes shown in tables.

Instrument Serial Prefix	Make Manual Changes
024-44032 and below	1
Below 024-	1, 2
003-31433 and below	1, 2, 3
Serials 21434-25833	1, 2, 3, 4

Instrument Serial Prefix	Make Manual Changes
Serial 21433 and below	1, 2, 3, 4, 5
Serials 04252 and below	1, 2, 3, 4, 5, 6

NOTE

-hp- Part No. and -hp- Stock No. are synonymous.

CHANGE #1

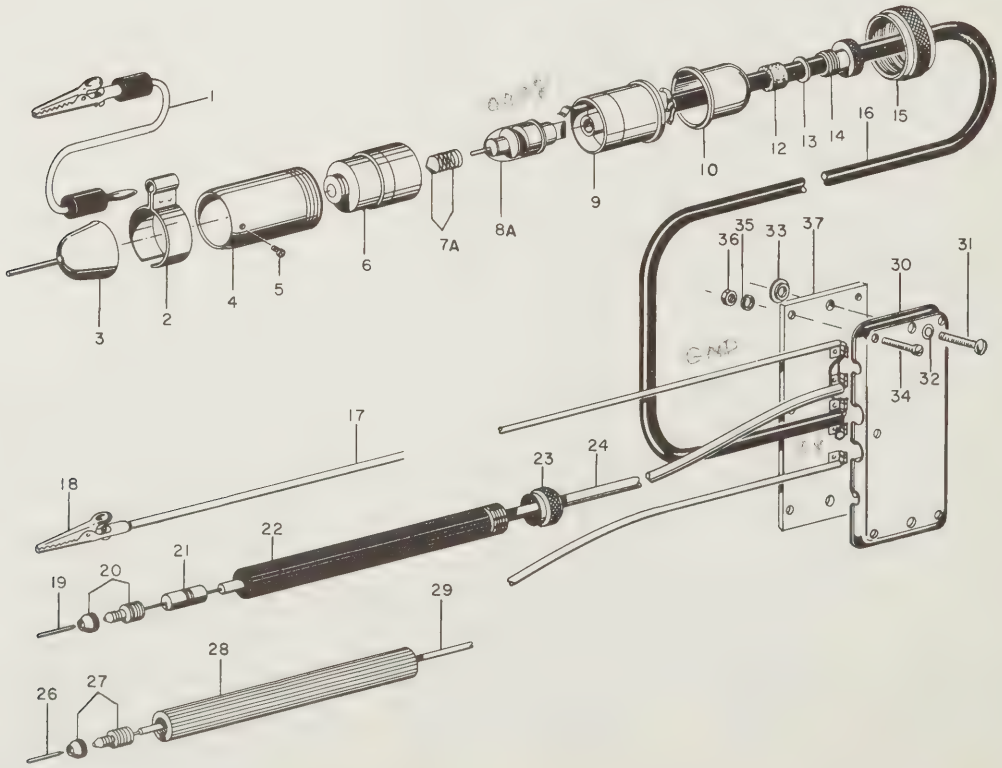
Table of Replaceable Parts and Figure 4-8
Change R27 and R29 to 270 ohms -hp- Part No. 0689-2715.
Change R26 and R30 to 680 ohms -hp- Part No. 0689-6815.

CHANGE #2

Table of Replaceable Parts and Figure 4-8
Change R49 and R50 to -hp- Part No. 2100-0035.
(-hp- Part No. 2100-0870 may be used in all instruments.)

CHANGE #3

Figure 4-1, Test Probe Assembly.
Change figure to the following:



Instrument Serial Prefix	Make Manual Changes
024-44032 and below	1
Below 024-	1, 2
003-31433 and below	1, 2, 3
Serials 21434-25833	1, 2, 3, 4

Instrument Serial Prefix	Make Manual Changes
Serial 21433 and below	1, 2, 3, 4, 5
Serial 04252 and below	1, 2, 3, 4, 5, 6

Section V, Table of Replaceable Parts

Change the -hp- Part No. for the following parts accor ing to reference designators. The parts not listed remain the same as the current probe.

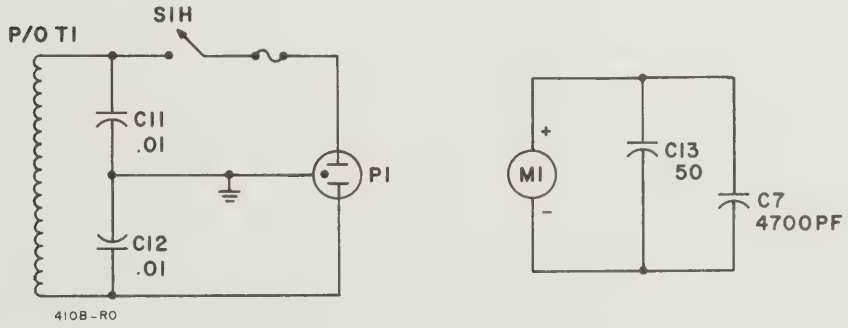
Designator	Description	-hp- Part No.
7A	Spring tip for 2-01C diode	410B-21N
8A	Diode, AC Probe, including spring tipe	1920-0008
10	Cap	42A-25G-1
12	Rubber washer 5/16 I.D. x 5/16 L.	0890-0011
13	Flat washer, brass 5/16 I.D. x 7/16 O.D.	3050-0022
14	Clamp nut	5020-0621
16	Coaxial Cable for AC Probe	8120-0006

Change #4

Delete R53 located in parallel with R19B.
(R53 may be added to make adjustment of R19B less sensitive)

Change #5

Add: R24 -hp- Part No. 0690-1061 connected in series with R23 -hp- Part No. 0689-2755 (R24, 10 megohms, +R23, 2.7 megohms, repleaces R23, 13 megohms).
Add: R53 Resistor fixed 2200 ohms -hp- Part No. 0690-2211, shunting R19B.
Change: C10 to 1 μf 600 v -hp- Part No. 0160-0079
Change: R32, R35, R39 and R40 to Resistor, var, ww, 500 ohms -hp-Part No. 2100-0054.
Change: R31 to Resistor, var, 1000 ohms, -hp- Part No. 2100-0004.
Add: C11, C12 Cap. fxd, paper, .01 μf -hp- Part No. 0160-0023.
C13 Cap. fxd, 50μf -hp- Part No. 0180-0029. (See partial schematic below for location).



Change: C7 to Cap. fxd. 4700 pf 500v -hp- Part No. 0140-0017.
C8 to Cap. fxd. 470 pf 500v -hp- Part No. 0140-0027.

Change #6

Change: R21 and R22 from 500 K to 470 K, -hp- Part No. 0686-4745.



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OPERATING AND SERVICING MANUAL

MODEL 410B

HIGH FREQUENCY
VACUUM TUBE
VOLTMETER

Serial 8355 and Above



HEWLETT-PACKARD COMPANY
275 Page Mill Road • Palo Alto, California, U.S.A.



INSTRUCTION AND OPERATING MANUAL

FOR

MODEL 410B

HIGH FREQUENCY VACUUM TUBE VOLTMETER

Serial 8355 and Above

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#410B002

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Figure 1-1. Model 410B

SECTION I

GENERAL DESCRIPTION

1-1. INTRODUCTORY

This instruction book contains the operating and maintenance instructions for the -hp- Model 410B High Frequency Voltmeter. A Table of Replaceable Parts in Section V contains information necessary for ordering parts from the Hewlett-Packard Company or another reliable supplier.

1-2. PURPOSE OF THE EQUIPMENT

The -hp- Model 410B is a laboratory quality volt-ohmmeter that has been especially designed for making accurate voltage measurements in the frequency range from 20 cycles per second to over 700 megacycles per second, with useful indications at frequencies as high as 1500 megacycles. In addition to measuring ac voltage, the 410B also measures dc voltages from 1 volt to 1000 volts and resistances from 1 ohm to 500 megohms.

The high accuracy obtained with all voltage measurements makes the -hp- Model 410B useful for a wide variety of laboratory. and field applications, especially in high frequency work. Construction of the ac probe is such as to enable the operator to minimize lead length and input capacity, factors which usually restrict the high frequency range in instruments of this type. The wide range of ac and dc voltage and resistance measurements combined with convenience of operation make the 410B very useful for all types of circuit testing and trouble shooting as well as development work.

1-3. EQUIPMENT SUPPLIED

The -hp- Model 410B is a completely self-contained test instrument which requires no additional equipment for operation. The unit consists of the multimeter, three test probes, a common grounding lead, and special grounding lead for use with the ac probe, shown assembled in Fig. 1-1.

1-4. GENERAL ELECTRICAL CHARACTERISTICS

The -hp- Model 410B measures ac voltages from 1 volt full-scale to 300 volts full-scale in the frequency range from 20 cycles to 60 megacycles and measures reduced voltages to 700 megacycles. The basic accuracy is ±3% for measurement of sine waves up to 60 megacycles per second, while the frequency response is ±1 db over the entire frequency range from 20 cycles to 700 megacycles per second. The 410B continues to be useful up to the probe resonant frequency of approximately 1500 megacycles, and indications can be obtained up to 3000 megacycles.

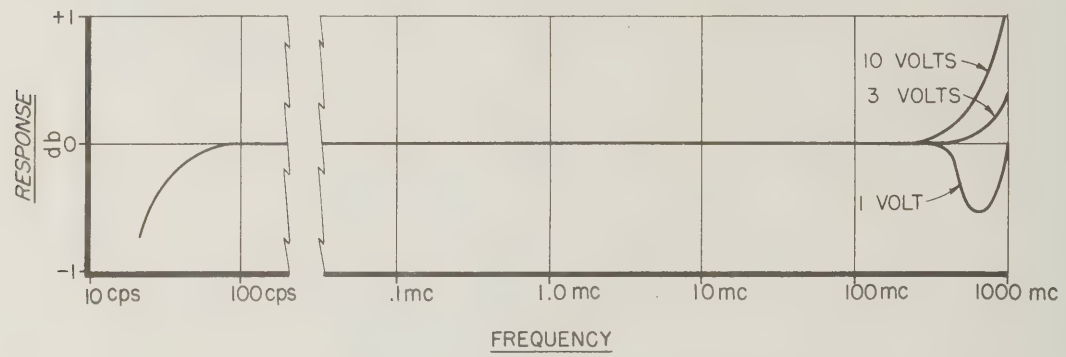


Fig. 1-2. Ratio of Indicated to Actual Voltage as a Function of Frequency

A performance curve for the probe, showing the ratio of indicated to actual voltage as a function of frequency, is plotted in Fig. 1-2. At low and medium frequencies the response is flat. At high frequencies, however, the response is affected by two factors: transit time of the probe diode, which is dependent upon the magnitude of the applied voltage; and the resonant frequency of the probe, which is independent of the applied voltage. The effect of transit time is indicated by the dip in the 1-volt curve in the vicinity of 500 mc. The rise of the 3-volt and 10-volt curves is due to the effects of resonance in the probe, which overshadow the effects of transit time.

The input resistance and shunt capacitive reactance components in the circuit within the ac probe are shown in the graph in Fig. 1-3. At low frequencies the input resistance exceeds 10 megohms, decreasing at higher frequencies because of dielectric and tube losses. The shunt capacity component of input impedance is approximately 1.5 micromicrofarads.

Dc voltages from 1 volt full-scale to 1000 volts full-scale in seven ranges can be measured with an accuracy of ±3% full-scale, with the unusually high input resistance of 122 megohms on all ranges. The shielded dc test cable minimizes pickup from stray fields. Resistance measurements can be made over the range from 500 ohms full-scale to 500 megohms full-scale in seven ranges, with sufficient overlap between ranges to assure a high percentage of upscale readings.

The -hp- Model 410B as shipped from the factory is connected for operation from a nominal 115-volt, single-phase ac power source. The power transformer primary windings may be reconnected as shown in the schematic diagram for 230-volt operation if desired. Power consumption is approximately 40 watts.

Complete specifications for the 410B are summarized in the Table of Specifications at the end of this section.

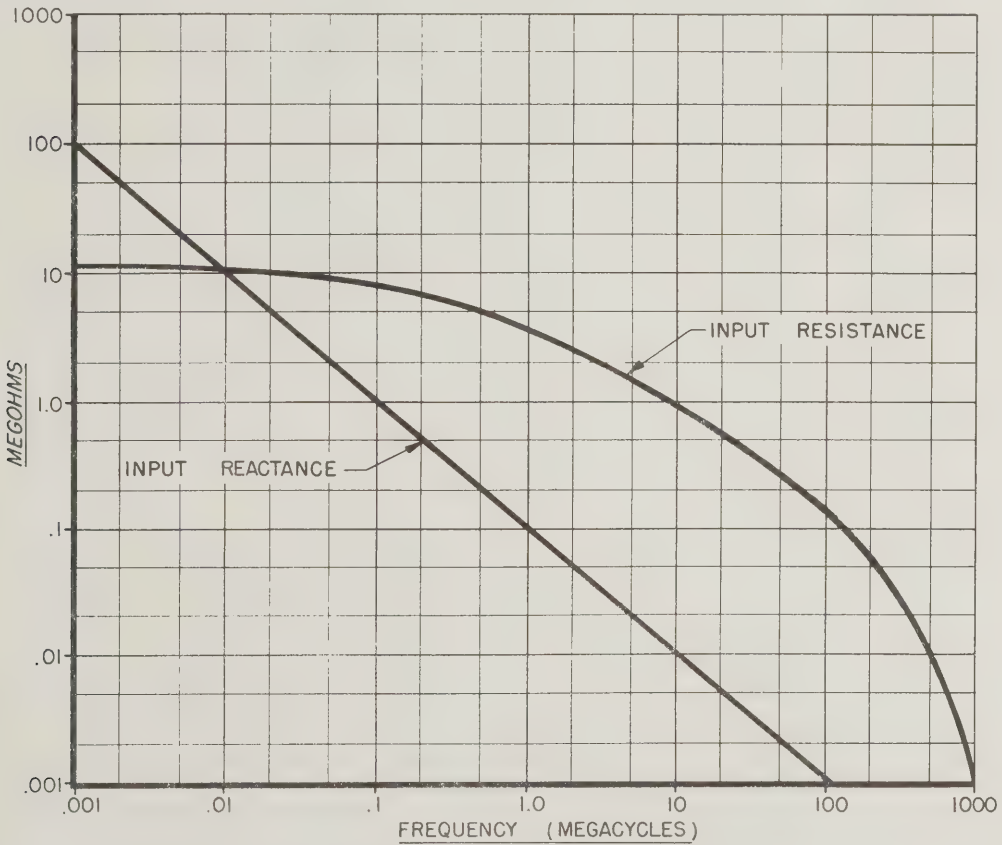


Fig. 1-3. Input Resistance and Reactance of Model 410B

1-5. DESCRIPTION

The -hp- Model 410B is a compact, portable electronic volt-ohmmeter which stands 11-1/2 inches high by 7-1/4 inches wide by 8 inches deep and weighs 12-1/4 pounds complete with test cables. The instrument and case are constructed of aluminum throughout and finished with a durable gray wrinkle lacquer. A leather carrying handle is provided on top of the instrument case, and four large rubber feet are attached to the bottom of the case for protection of table surfaces.

For maximum portability a compartment is provided in the rear of the multimeter cabinet for storing the test leads when not in use. The multimeter employs a separate test probe for each type of measurement, DC, AC and OHMS. A single clip lead provides the negative or ground terminal for all three test probes. For high frequency measurements, where grounding is critical, a short, heavy ground clip lead is provided on the shell of the ac probe, thereby eliminating lengthy and inefficient ground loops. The power cord which is not removable is located in the rear of the instrument.

To permit ac voltage measurements to the highest frequency practicable, the ac probe is specially designed for minimum lead length and minimum input capacity. The diode tube used within the probe is a special tube designed to have a very high resonant frequency, thereby extending its useful measuring range. Further, the probe body has been designed so that the input blocking capacitor is removable by unscrewing the plastic nose of the probe. Then, by using an external blocking capacitor of the button type, the length of the circuit to the diode can be so reduced that the resonant frequency of the circuit is extended to the highest possible value. Useful measurements may be made to frequencies as high as 1500 megacycles when the probe is used properly in conjunction with the measured circuits.

All operating controls for the multimeter are located in plain view on the front panel. A function SELECTOR switch provides the type of operation desired — AC, DC or OHMS measurement — selects the appropriate probe, and also provides for reading either positive or negative dc voltages without reversal of the test leads. A seven-position RANGE selector switch selects and indicates the full-scale value of voltage or resistance and provides sufficient overlapping of resistance ranges for a high percentage of up-scale readings. No batteries are required for ohmmeter measurements, the internal voltages being supplied from the instrument power supply. The multimeter utilizes a 4-inch wide meter marked with five scales. All ac and dc voltage ranges, except the 1-volt and 3-volt ac ranges, are read on two black-lettered meter scales, calibrated 0 to 1 and 0 to 3. The 1-volt and 3-volt ac ranges

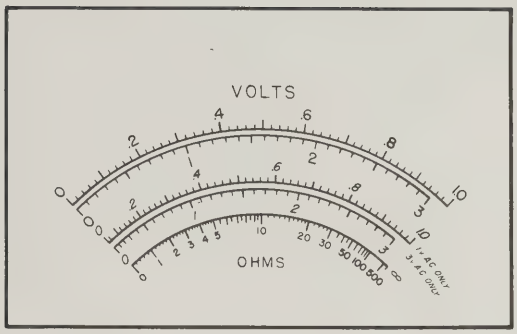


Fig. 1-4. Meter Scale Calibration in Model 410B

are read from two separate ac scales calibrated in red letters. For ac measurements the meter indicates rms values of sine waves. All resistance ranges are read on a single separate ohm scale calibrated from 0 to 500.

The rear panel of the instrument case is removable without tools and, when removed, permits access to the instrument fuse, cable compartment, and important internal adjustments. The chassis and front panel of the multimeter are removable from the case by removing the two screws on the panel inside the rear of the instrument and drawing the front panel and chassis out of the case. The instrument is ventilated by louvers in the sides and back of the instrument case.

SPECIFICATIONS FOR MODEL 410B

Voltage Ranges

Volts Full Scale

1, 3, 10, 30, 100, 300 volts alternating current.

1, 3, 10, 30, 100, 300, 1000 volts direct current.

Resistance Scale Calibration

0 - 500 (∞)

Range

Rx1	.2 to 500 ohms
Rx10	2 to 5000 ohms
Rx100	20 to 50,000 ohms
Rx1K	200 to 500,000 ohms
Rx10K	2000 to 5 megohms
Rx100K	20,000 to 50 megohms
Rx1M	200,000 to 500 megohms

Calibration Accuracy

±3% of full-scale on all ranges with dc voltages and sinusoidal ac voltages to 60 megacycles.

Frequency Response

The frequency response is flat within +1 db from 20 cycles to 700 megacycles per second. The probe resonant frequency is about 1500 mc and an indication can be obtained up to 3000 mc.

Input Impedance

Alternating Current — The input capacitance of the ac measurement probe is 1.5 mmf and the input resistance is 10 megohms at low frequencies. At high frequency the resistance decreases due to dielectric losses.

Direct Current — The input resistance of the dc measurement probe is 122 megohms for all ranges.

Power Supply Rating

Voltage — 115/230 volts
Frequency — 50/60 cycles/sec
Wattage — 40 watts

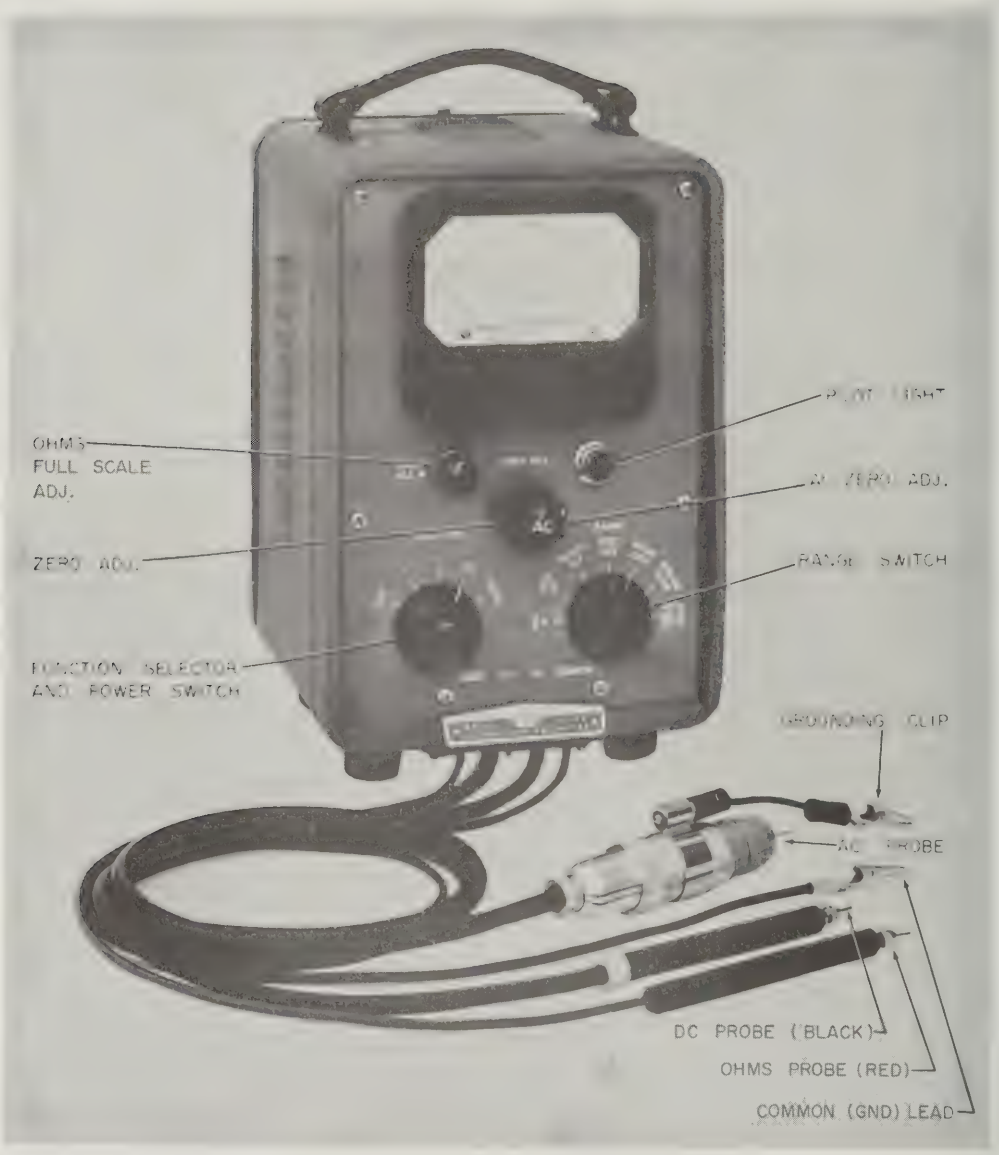


Fig. 2-1. Model 410B, Controls and Terminals Labeled

SECTION II

OPERATING INSTRUCTIONS

2-1. INSPECTION

This instrument has been thoroughly tested and inspected before being shipped from the factory and is ready for use when received. When the instrument is unpacked, it should be carefully inspected for damage received in transit. In case of shipping damage, follow the procedure outlined in the "Claim for Damage in Shipment" page at the back of this manual.

2-2. INSTALLATION

The -hp- Model 410B is shipped from the factory with the test probe assembly disconnected and stored in the compartment inside the rear of the instrument case. To assemble the multimeter, remove probe and cable assembly from the compartment in the rear of the instrument case, connect probe assembly to the jack in the bottom of the instrument, and tighten the two round head retaining screws at either end of the plug.

2-3. OPERATING CONTROLS AND TERMINALS

A description of each of the front panel controls, the test probes, and the meter follows.

SELECTOR This five-position switch turns the instrument on; provides for measurements of negative or positive d-c voltage, a-c voltage, or resistance; and connects the appropriate probe for the desired measurement.

RANGE This switch selects the full-scale voltage or resistance range to be used.

ZERO ADJ. The larger, fluted knob with the white dot is a basic zero adjustment that sets the meter pointer to zero when the SELECTOR switch is set at - and +. The smaller knob marked AC is used to set the meter pointer to zero following the basic zero adjustment and with the SELECTOR switch set to AC.

OHMS ADJ.∞ This knob adjusts the meter pointer to full scale (∞) when the SELECTOR switch is set to OHMS.

OHMS, AC, DC, COMMON The designations at the bottom of the control panel identify the various test leads, which are connected underneath the instrument. The connector can be removed by unscrewing the two captive round head screws in either end of the connector. Once installed, the three probes need not be removed, although only the one probe in use is connected through the SELECTOR switch to the internal circuits. Each probe has the specialized function described below.

OHMS The red rubber-covered cable with the red plastic prod is used in measuring resistance. The prod is equipped with a small chuck to hold a steel phonograph needle. The instrument is shipped from the factory with the sharp point of the needle inside the chuck and can be reversed if it is necessary to employ a sharp point for good connection.

AC A cable that terminates in the shielded probe is used for ac voltage measurements. The probe tip contacts the point in a circuit where a voltage is to be measured and the clip lead on the probe connects to the ground side of the circuit.

DC The black, shielded cable with the black plastic prod is used to measure dc voltages. The prod is equipped with a small chuck to hold a steel phonograph needle. The instrument is shipped from the factory with the sharp point of the needle inside the chuck and can be reversed if it is necessary to employ a sharp point for good connection.

COMMON The black rubber-covered wire terminated in an alligator clip is the negative connection for all measurements except those made with the clip lead on the end of the AC probe. The common lead is connected directly to the chassis of the instrument.

FUSE The fuseholder, located behind the cover in the rear compartment of the instrument, contains a 0.4 amp slow-blow cartridge fuse replaceable by unscrewing the fuse-holder cap and inserting a new fuse. A 0.5 amp instantaneous-blow fuse should be used if the instrument is operated on 230 volts.

Power Cable The power cable, leading out of the rear of the instrument case, contains three conductors, two of which carry power to the instrument. The third wire, connected directly to the chassis, projects from the plug end of the cable and can be connected to an ac outlet mounting box when it is desired to hold the chassis of the multimeter at ground potential.

2-4. OPERATING ADJUSTMENTS

The -hp- Model 410B has three front panel operating adjustments: ZERO ADJ., AC ZERO ADJ., and OHMS ADJ.∞. ZERO ADJ. sets the

meter pointer to zero when the selector switch is in the - and in the + positions and must be adjusted before the AC and the OHMS adjustments are made. AC ZERO ADJ. adjusts the meter pointer to zero when the selector switch is in the AC position to compensate for any small residual meter reading that appears as the ac probe is switched into operation. OHMS ADJ. ∞ sets the meter pointer to full-scale when the selector switch is turned to the OHMS position.

2-5. STEP-BY-STEP OPERATING PROCEDURES

Basic Zero Adjustment

a) Connect the power cable to the power line. Set the SELECTOR switch to the - position and allow instrument to heat for five minutes for stable operation.

b) Connect the DC and COMMON test leads together.

c) Adjust the ZERO ADJ. (fluted knob) control so that the meter indicates zero with the SELECTOR switch set to a low-voltage range.

d) Set the SELECTOR switch to + and note the meter reading. If the needle point has shifted, set ZERO ADJ. so that the needle returns to the same position for both - and + positions of the SELECTOR switch.

AC Zero Adjustment

a) Make the Basic Zero Adjustment described above.

b) Set the SELECTOR switch to AC and set the RANGE switch to the 1V position.

c) Connect the AC probe clip lead to the probe tip.

d) Adjust the AC knob to bring the meter pointer to 0.

OHMS Full-Scale and Zero Adjustments

a) Make the Basic Zero Adjustment described above.

b) Set the SELECTOR switch to OHMS.

c) Adjust the OHMS ADJ. ∞ control so that the meter pointer indicates ∞ on the ohms scale. The OHMS and COMMON test leads must not be connected together when making this adjustment.

d) To use the ohmmeter without making the basic zero or AC adjustments, connect the OHMS and COMMON test leads together, set the RANGE switch to RX1K or higher range, and adjust the ZERO ADJ. (fluted knob) until the meter pointer indicates zero on the ohms scale.

The multimeter is now ready for operation. Before attempting to make an actual measurement, study the operating procedures described in the paragraphs below.

CAUTION

The voltmeter COMMON and the AC probe ground clip lead are connected directly to the chassis of the Multimeter. When making voltage measurements — ac or dc, positive or negative — always connect the voltmeter COMMON or the AC probe ground clip lead to the chassis, or ground, of the equipment under test. Connecting the COMMON test lead to a point of ac or dc potential places the Multimeter cabinet at that potential and thereby presents a hazard to operating personnel. To hold the instrument cabinet at ground potential, it is recommended that the green pigtail termination on the Multimeter power cord be grounded to the ac outlet mounting box.

Procedure for Measuring DC Voltages

a) Make the basic zero adjustment described earlier in this paragraph.

b) Set the SELECTOR switch to either the + or - position, depending upon the polarity of the voltage to be measured.

c) Set the RANGE switch to the range that includes the voltage to be measured.

d) Connect the COMMON test lead to the ground side of the circuit to be measured and touch the DC volts prod to the point in the circuit being measured.

e) Read the measured voltage from the meter, multiplying the indicated value by the appropriate factor. Dc voltages are read from the two top meter scales, 0 - 1 and 0 - 3, printed in black.

meter pointer to zero when the selector switch is in the - and in the + positions and must be adjusted before the AC and the OHMS adjustments are made. AC ZERO ADJ. adjusts the meter pointer to zero when the selector switch is in the AC position to compensate for any small residual meter reading that appears as the ac probe is switched into operation. OHMS ADJ. ∞ sets the meter pointer to full-scale when the selector switch is turned to the OHMS position.

2-5. STEP-BY-STEP OPERATING PROCEDURES

Basic Zero Adjustment

a) Connect the power cable to the power line. Set the SELECTOR switch to the - position and allow instrument to heat for five minutes for stable operation.

b) Connect the DC and COMMON test leads together.

c) Adjust the ZERO ADJ. (fluted knob) control so that the meter indicates zero with the SELECTOR switch set to a low-voltage range.

d) Set the SELECTOR switch to + and note the meter reading. If the needle point has shifted, set ZERO ADJ. so that the needle returns to the same position for both - and + positions of the SELECTOR switch.

AC Zero Adjustment

a) Make the Basic Zero Adjustment described above.

b) Set the SELECTOR switch to AC and set the RANGE switch to the 1V position.

c) Connect the AC probe clip lead to the probe tip.

d) Adjust the AC knob to bring the meter pointer to 0.

OHMS Full-Scale and Zero Adjustments

a) Make the Basic Zero Adjustment described above.

b) Set the SELECTOR switch to OHMS.

c) Adjust the OHMS ADJ. ∞ control so that the meter pointer indicates ∞ on the ohms scale. The OHMS and COMMON test leads must not be connected together when making this adjustment.

d) To use the ohmmeter without making the basic zero or AC adjustments, connect the OHMS and COMMON test leads together, set the RANGE switch to RX1K or higher range, and adjust the ZERO ADJ. (fluted knob) until the meter pointer indicates zero on the ohms scale.

The multimeter is now ready for operation. Before attempting to make an actual measurement, study the operating procedures described in the paragraphs below.

CAUTION

The voltmeter COMMON and the AC probe ground clip lead are connected directly to the chassis of the Multimeter. When making voltage measurements — ac or dc, positive or negative — always connect the voltmeter COMMON or the AC probe ground clip lead to the chassis, or ground, of the equipment under test. Connecting the COMMON test lead to a point of ac or dc potential places the Multimeter cabinet at that potential and thereby presents a hazard to operating personnel. To hold the instrument cabinet at ground potential, it is recommended that the green pigtail termination on the Multimeter power cord be grounded to the ac outlet mounting box.

Procedure for Measuring DC Voltages

a) Make the basic zero adjustment described earlier in this paragraph.

b) Set the SELECTOR switch to either the + or - position, depending upon the polarity of the voltage to be measured.

c) Set the RANGE switch to the range that includes the voltage to be measured.

d) Connect the COMMON test lead to the ground side of the circuit to be measured and touch the DC volts prod to the point in the circuit being measured.

e) Read the measured voltage from the meter, multiplying the indicated value by the appropriate factor. Dc voltages are read from the two top meter scales, 0 - 1 and 0 - 3, printed in black.

CAUTION

Before measuring voltages above fifty megacycles, consult the 410B probe voltage rating graph "Maximum Applied Voltage vs. Frequency" (Fig. 2-2). To obtain accurate and dependable ac voltage measurements, certain precautions must be observed that are not readily apparent. These precautions are described in paragraph 2-6.

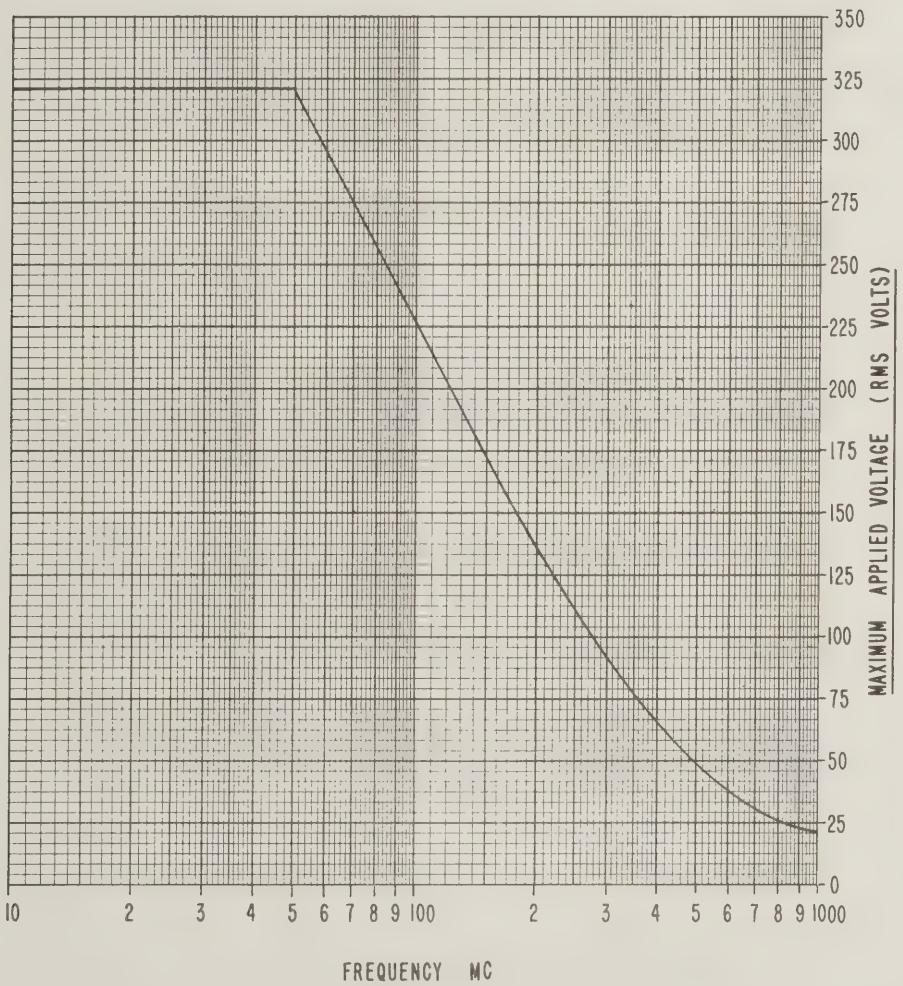


Fig. 2-2. Maximum Voltage That Can Safely Be Applied to AC Probe for Frequencies Above 50 Megacycles

Procedure for Measuring AC Voltages

a) Make the AC zero adjustment described above.

b) Set the RANGE switch to the range that includes the voltage to be measured.

c) Connect the ground clip lead on the ac probe to ground of the circuit being measured and touch the ac probe tip to the other side of the circuit being measured. (For audio frequencies the ground lead from the voltmeter chassis may be used for negative connection instead of the ground lead on the ac probe, if desired.)

d) The measured voltage is then read from the meter. The full-scale value of the meter is indicated by the setting of the RANGE switch.

NOTE

The 0 - 1V and 0 - 3V meter scales printed in red are for use only with the 1V and 3V ac positions of the RANGE switch. The remainder of the alternating voltage ranges are read from the two top meter scales (0 - 1 and 0 - 3) printed in black.

Procedure for Measuring Resistances

CAUTION

Turn off equipment that is to be tested before making resistance measurements. Be sure that no residual voltages remain in the circuit being measured.

a) Make the OHMS adjustment described earlier in this paragraph.

b) Set the SELECTOR switch to the OHMS position.

c) Connect the COMMON and OHMS test leads to the resistance to be measured.

d) Set the RANGE switch to the position that gives the largest up-scale meter indication.

e) Read resistance value from bottom scale on meter. The resistance is equal to the scale indication times the multiplying factor shown by the position of RANGE selector.

2-6. AC MEASUREMENT PRECAUTIONS

Special considerations must be kept in mind when making high-frequency ac voltage measurements. These considerations are discussed in the following paragraphs.

General Consideration of Complex Waveforms

Waveforms containing appreciable harmonics or spurious voltages will introduce errors in the meter indication since the meter has been calibrated to read rms values of true sine waves while the ac probe is a peak-reading device. The magnitude of error that may be expected when harmonics are present on the measured waveform is indicated in the table below.

Possible Error When Measuring
Voltage of Complex Waveforms

% Harmonic	True RMS Value	Model 410B Indication
0	100	100
10% 2nd	100.5	90 to 110
20% 2nd	102	80 to 120
50% 2nd	112	75 to 150
10% 3rd	100.5	90 to 110
20% 3rd	102	87 to 120
50% 3rd	112	108 to 150

Voltage Measurements at Frequencies Below 50 Cycles/Second

Voltage measurements at frequencies as low as 10 cycles per second may be made to the unit's basic accuracy by removing the plastic nose on the ac probe and using in its place a blocking capacitor of 0.25 microfarad in series with the exposed contact of the probe.

CAUTION

The gray insulating material of the probe of the 410B is polystyrene, a low melting-point material. It is not possible to solder to the contact which is exposed when the probe nose is removed without destroying the polystyrene.

Voltage Measurements at High Frequencies

At frequencies above 100 megacycles the distance between the point of voltage measurement and the anode contact of the ac probe must be made as short as possible. If feasible, substitute a small button-type capacitor of approximately 50 micromicrofarads for the removable tip on the ac probe. Solder one terminal of the button capacitor to the measurement point in the circuit and not to the probe contact. The probe contact (with tip removed) can then contact the other terminal of the capacitor for the measurement.

At frequencies above 100 megacycles considerable voltage may be built up across ground leads and along various parts of a grounding plane. Consequently, to avoid erroneous readings when measuring medium and high frequency circuits, use the ground clip lead on the shell of the probe. In some cases at the higher frequencies it may be necessary to shorten still further the grounding lead on the shell of the probe.

For all measurements at the higher frequencies hold the molded nose of the probe as far from the external ground plane or from objects at ground potential as can conveniently be done. Under typical conditions, this practice will keep the input capacitance several tenths of a micromicrofarad lower than will be obtained otherwise.

For ac measurements above approximately 250 megacycles it is nearly mandatory that measurements be made on voltages which are confined to coaxial transmission line circuits. For applications of this type, the -hp- Model 410B is particularly suitable because the physical configuration of the diode and probe is that of a concentric line, and with a few precautions it can be connected to typical coaxial transmission line circuits with little difficulty.

To connect the -hp- Model 410B into an existing coaxial transmission line, cut the line away so the center conductor of the line is exposed through a hole large enough to clear the body of the ME-26A/U ac probe. The nose of the probe should be removed for this type of measurement. Connect one terminal of a button-type

capacitor of approximately 50 micromicrofarads to the center conductor of the coaxial line so that the other terminal of the capacitor will contact the anode connection of the probe. A close-fitting metal shield or bushing should be arranged to ground the outer cylinder of the probe to the outer conductor of the transmission line. This type of connection is likely to cause some increase in the standing wave ratio of the line at higher frequencies. It is desirable, where the frequency is high and where good accuracy is required, to make some impedance matching modifications on the transmission line to minimize reflected power from the point of measurement.

Effect of Parasitics on Voltage Readings

At frequencies above 500 megacycles, leads or portions of circuits often resonate at frequencies two, three or four times the fundamental of the voltage being measured. These harmonics may cause serious errors in the meter reading. Owing to the resonant rise in the probe circuit at frequencies above 1000 megacycles, the meter may be more sensitive to the harmonics than to the fundamental. To make dependable measurements at these frequencies, the circuits being measured must be free of all parasitics.

2-7. PULSE MEASUREMENTS

The 410B is a peak-reading rms indicating type voltmeter and is designed to measure the positive peak value of the applied voltage. This property allows the -hp- Model 410B to be used to measure the positive voltage amplitude of a pulse, provided the reading obtained is multiplied by the following factor:

$$1.4\left(1 + \frac{t_1}{t_2} + \frac{K}{PRF}\right)$$

Where: t_1 is the duration of the positive portion of the voltage, in microseconds,

t_2 is the duration of the negative portion of the voltage,

K is a factor which is a function of the source impedance of the pulse generator and of t_1, and is found in the graph of Fig. 2-3,

PRF is the pulse repetition frequency in pulses per second.

In general this equation is applicable where the pulse repetition frequency is greater than 500 pulses per second and the positive pulse duration is at least 10 microseconds. For most cases when using high pulse repetition rates, the above factor will reduce to

$$1.4(1 + \frac{t_1}{t_2})$$

K can be found by use of the curves in Fig. 2-3 when the impedance of the pulse generator R_o in kilohms and the duration of the positive portion of the pulse t_1 in microseconds are known. As an example,

Suppose: t_1 = 10 microseconds,

R_o = 2 kilohms and the pulse repetition frequency is 1000 pulses per second,

then $R_o/t_1 = 0.2$, K = 0.55, and the multiplying factor would then be

$$1.4(1 + \frac{10}{990} + \frac{0.55}{1000}).$$

For the case of a 10 microsecond negative pulse and a pulse repetition frequency of 1000 pulses per second, t_1 would be 990 microseconds and t_2 would equal 10 microseconds. Thus, R_o/t_1 would be approximately 0, and therefore (from Fig. 2-3) K would also be approximately 0. The multiplying factor would then be

$$1.4(1 + 990/10).$$

Hence, it may be seen that in the case of negative pulses of short duration much smaller readings will be obtained than for an equivalent positive pulse. As a result, large multiplying factors must be used and unless the pulse voltage is large, these measurements may be impractical.

2-8. ACCESSORIES AVAILABLE BUT NOT SUPPLIED

Several accessories may be used to extend the ac and dc voltage range of the 410B and to facilitate voltage measurements in coaxial lines. These accessories are available from the Hewlett-Packard Company. A description of these accessories and their specifications is contained in the paragraphs below; the accessories are shown in Fig. 2-4, a-e.

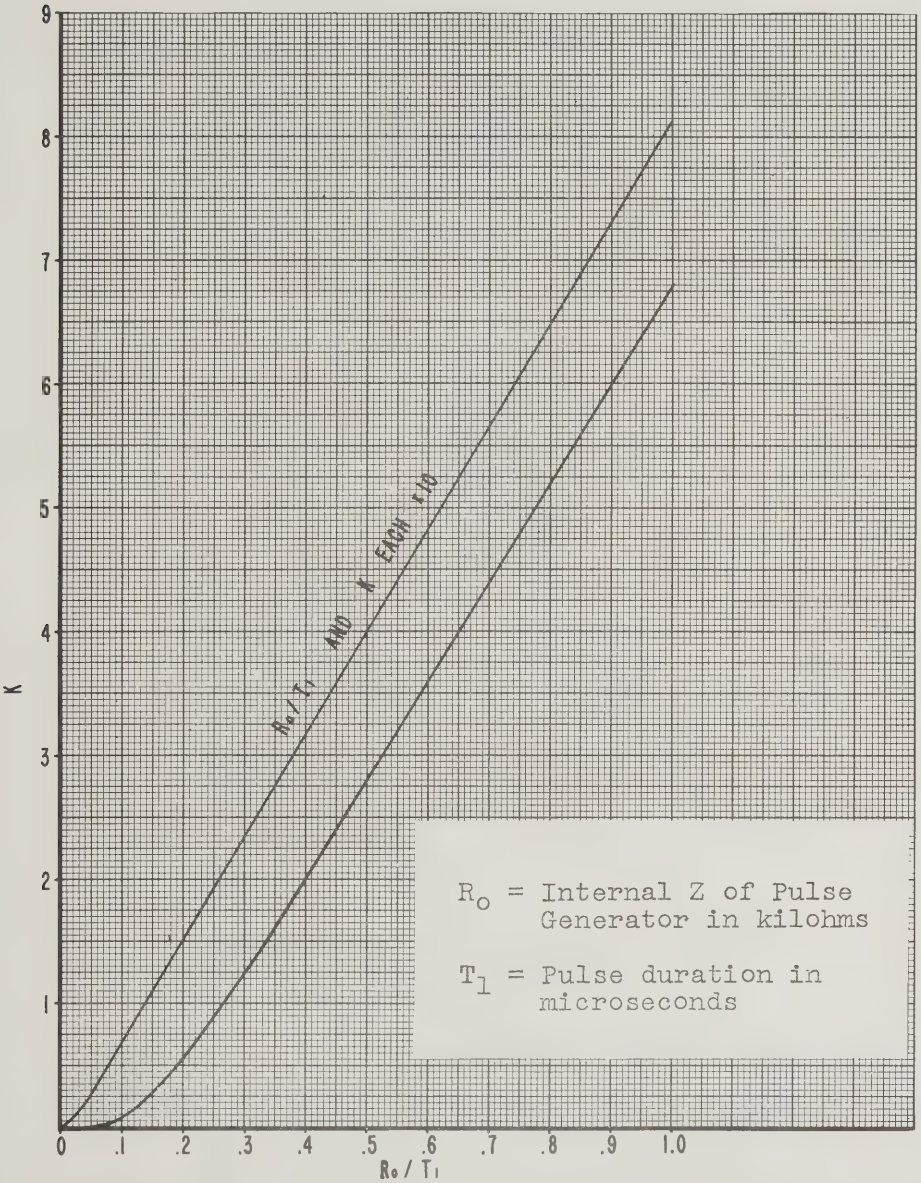


Fig. 2-3. Graph Used in Calculation of Pulse Voltages

Model 453A Capacitive Voltage Divider

The Model 453A Capacitive Divider shown in Fig. 2-4a extends the ac voltage range of the ME-26A/U Multimeter to 2000 volts rms. The divider is for use at frequencies above 10 kilocycles. Voltage division is 100:1, ±1%, and the input capacity is approximately 2 micromicrofarads.

Model 452A Capacitive Voltage Divider

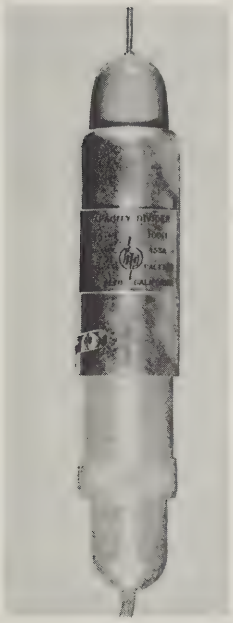
The Model 452A Capacitive Divider shown in Fig. 2-4b extends the ac voltage range of the ME-26A/U Multimeter to as much as 25 kilovolts. This divider permits measurement of extremely high ac voltages such as are encountered in dielectric heating equipment and similar applications. The frequency range of the divider is from 25 cps to 20 mc, although as frequency increases, the divider is de-rated to limit the r-f current flowing through its capacitors. A fixed gap is provided so that breakdown will occur if the applied voltage exceeds about 28 kv at low frequencies. Voltage division is 1000:1, ±3%, and the input capacity is 15 micromicrofarads.

Model 458A Probe Coaxial "N" Connector

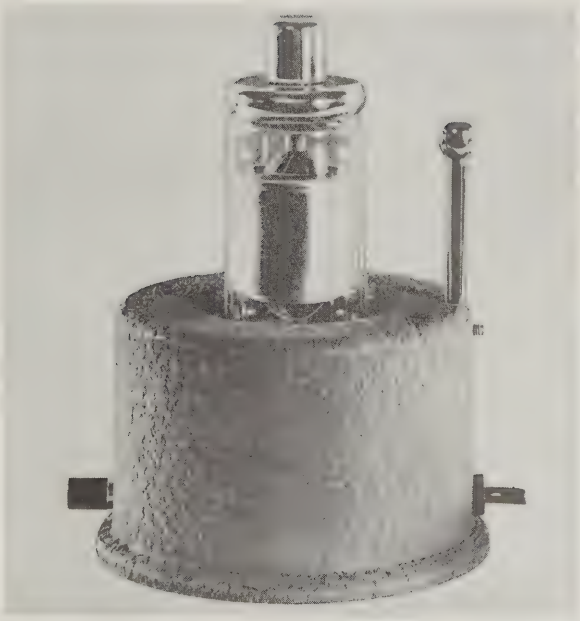
The Model 458A coaxial connector shown in Fig. 2-4c allows the ac probe of the ME-26A/U Multimeter to be connected to a 50-ohm coaxial line at a junction where type N connectors are used. The "T" connector contains male and female type N connectors for the input and output jacks and a receptacle for receiving the ac probe of the ME-26A/U Multimeter. The "T" can also be used at the end of a line; however, no terminating resistor is included.

Model 455A Coaxial "T" Connector

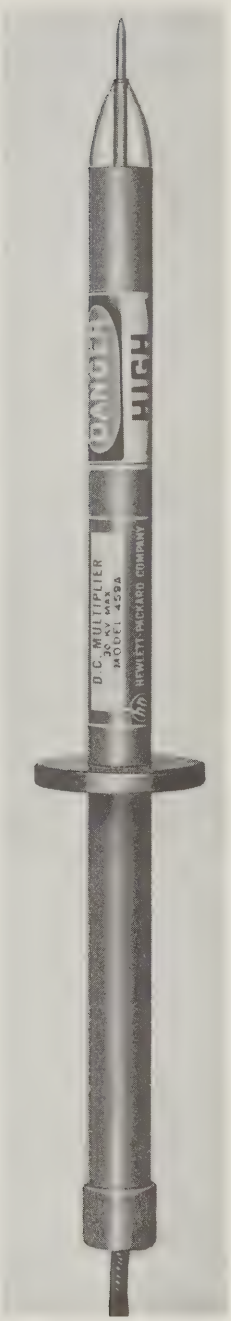
For measurements at the higher frequencies the special T-joint shown in Fig. 2-4d has been designed for connecting the ME-26A/U Multimeter across a 50-ohm transmission line using type N connectors. The T-joint has been designed so that the connection of the multimeter into a transmission line circuit will not cause a standing wave ratio greater than 1.1 at 500 megacycles and 1.2 at 1000 megacycles. With the aid of this device, measurement of power traveling through a transmission line may be made with reasonable accuracy to 1000 mc. The usual precautions must be taken to provide accurate impedance matching and the elimination of standing waves along the line through which power is flowing. By using a dummy load at the receiving end of this T-joint, power output of various devices can be measured. In many applications, power going into a real load, such as an antenna, can be conveniently measured up to frequencies as high as 1000 megacycles with good accuracy.



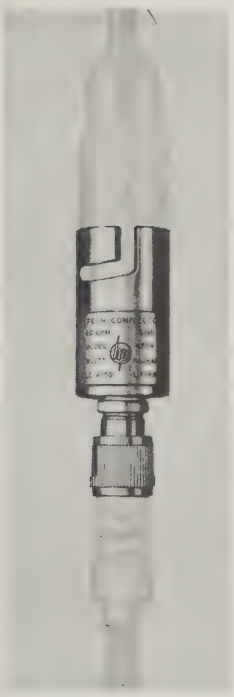
a) Model 453A Capacitive Voltage Divider



b) Model 452A Capacitive Voltage Divider



e) Model 459A DC Resistive Voltage Multiplier



c) Model 458A Probe Coaxial "N" Connector



d) Model 455A Coaxial "T" Connector

Figure 2-4. Accessories for -hp- Model 410B

Model 459A DC Resistive Voltage Multiplier

The Model 459A dc voltage multiplier shown in Fig. 2-4e extends the dc voltage range of the -hp- Model 410B to a maximum of 30 kilovolts. Multiplication ratio is 100:1, ±5%, and the input impedance is 12,000 megohms. This probe offers maximum safety and convenience for measuring high voltages such as in television equipment, etc. The maximum current drain is 2.5 microamperes.

2-9. RESISTANCE MEASUREMENT ABOVE 500 MEGOHMS

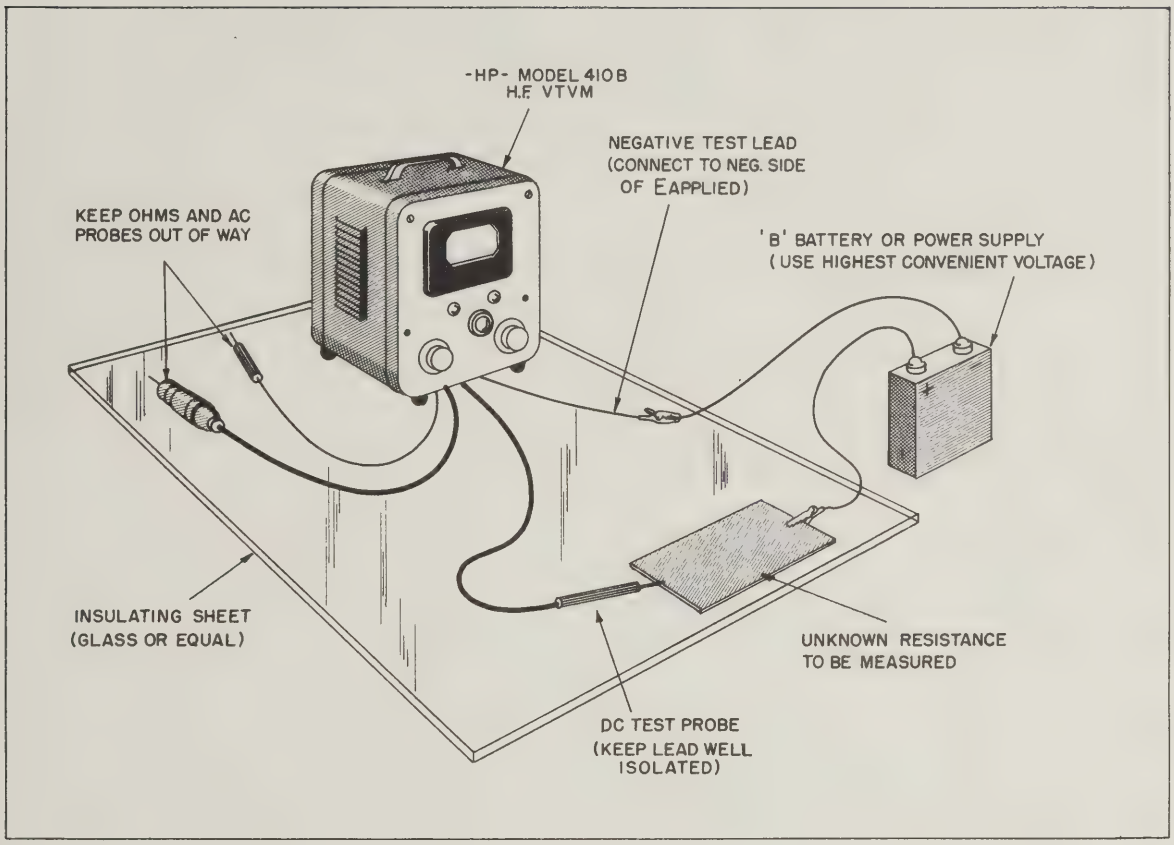
Because of its very high input resistance the Model 410B, supplemented by an external voltage, can be used to measure extremely high resistances. Any convenient d-c voltage up to 1000 volts may be used, the higher voltages permitting measurement of higher resistances. A 45-volt "B" battery extends the resistance measurement range to approximately 250,000 megohms. Resistances as high as several million megohms are easily and accurately made when the leakage between the test leads is held to a minimum by careful placement. The highest resistance that can be measured is limited by the total leakage between the DC test probe and the COMMON test probes on the voltmeter.

The measurement of extremely high resistance is accomplished by applying a known d-c voltage to the unknown resistance in series with the 410B as shown in the illustration on the following page. The external voltage is first measured with the 410B and recorded. The positive side of the external voltage source is then connected through unknown resistance to the d-c measurement probe, the negative side of the voltage is connected to the COMMON lead from the 410B. The voltmeter range switch is then adjusted to obtain an upscale voltage reading. The meter indicates the voltage across the 122 megohm input resistance, which when multiplied by the ratio of the applied voltage to the measured voltage, minus one, gives the resistance of the unknown. The equation for determining an unknown resistance for any supply voltage and meter reading is given in the following equation. When the ratio of E applied to E measured is greater than 100:1, the minus one may be dropped with no practical loss in accuracy.

$$\left(\frac{E_{bb}}{E_m} - 1\right) R_m$$

E_{bb} = Externally applied battery or power supply voltage
E_m = Voltage read on d-c volts scale of voltmeter
R_m = Input resistance of voltmeter

(410A = 100 megohms)
(410B = 122 megohms)


-HP- MODEL 410B
H.F VTVM
NEGATIVE TEST LEAD
(CONNECT TO NEG. SIDE
OF EAPPLIED)
KEEP OHMS AND AC
PROBES OUT OF WAY
'B' BATTERY OR POWER SUPPLY
(USE HIGHEST CONVENIENT VOLTAGE)
INSULATING SHEET
(GLASS OR EQUAL)
UNKNOWN RESISTANCE
TO BE MEASURED
DC TEST PROBE
(KEEP LEAD WELL
ISOLATED)

SECTION III

THEORY OF OPERATION

3-1. GENERAL

The -hp- Model 410B is designed to measure the amplitude of a-c and d-c voltages and the values of resistances. To accomplish these measurements, the equipment's circuit is arranged as indicated by the block diagram of Fig. 3-1. When measuring d-c voltages, the voltage to be measured is applied through a precision voltage divider to the input of a differential d-c amplifier. The output of the amplifier feeds a balanced bridge which has an indicating meter connected between the mid-points. The magnitude of deflection of the meter is thus proportional to the amplitude of the d-c voltage applied to the input of the differential amplifier.

When measuring a-c voltages, the voltage to be measured is converted to a d-c voltage in a special wide-band rectifier circuit. The output of the rectifier is then applied to the d-c voltage-measuring circuit described above. A deflection of the indicating meter then occurs in proportion to the amplitude of the a-c voltage being measured.

For measuring resistances, a small d-c voltage from the voltmeter power supply is applied to a circuit consisting of the unknown resistance connected in series with a known resistance. The proportion of the internal voltage that appears across the unknown resistance is thus related to the value of the unknown resistance. The voltage across the unknown resistance is then applied to the input of the differential amplifier as before with the result that the magnitude of meter deflection is related to the value of the resistance being measured.

3-2. R-F RECTIFIER

The circuit used for rectifying a-c signal voltages is shown in Fig. 3-2. The circuit is a half-wave shunt-detector type circuit which operates to charge the small input coupling capacitor C1 to the peak value of the positive half of the a-c voltage being measured. To smooth the rectified a-c voltage for application to the differential amplifier, a large resistor (22 megohms) and capacitors C2 and C3 are connected across the output of the rectifier. The voltage across the capacitors rises to the peak value of the rectified wave and is applied through the precision voltage divider to the d-c amplifier.

Since the voltmeter is designed to be capable of measuring high frequencies, the rectifier circuit is built in the form of a probe so that it can be physically placed close to the point of measurement. The probe connects to the voltmeter proper through a flexible cable.

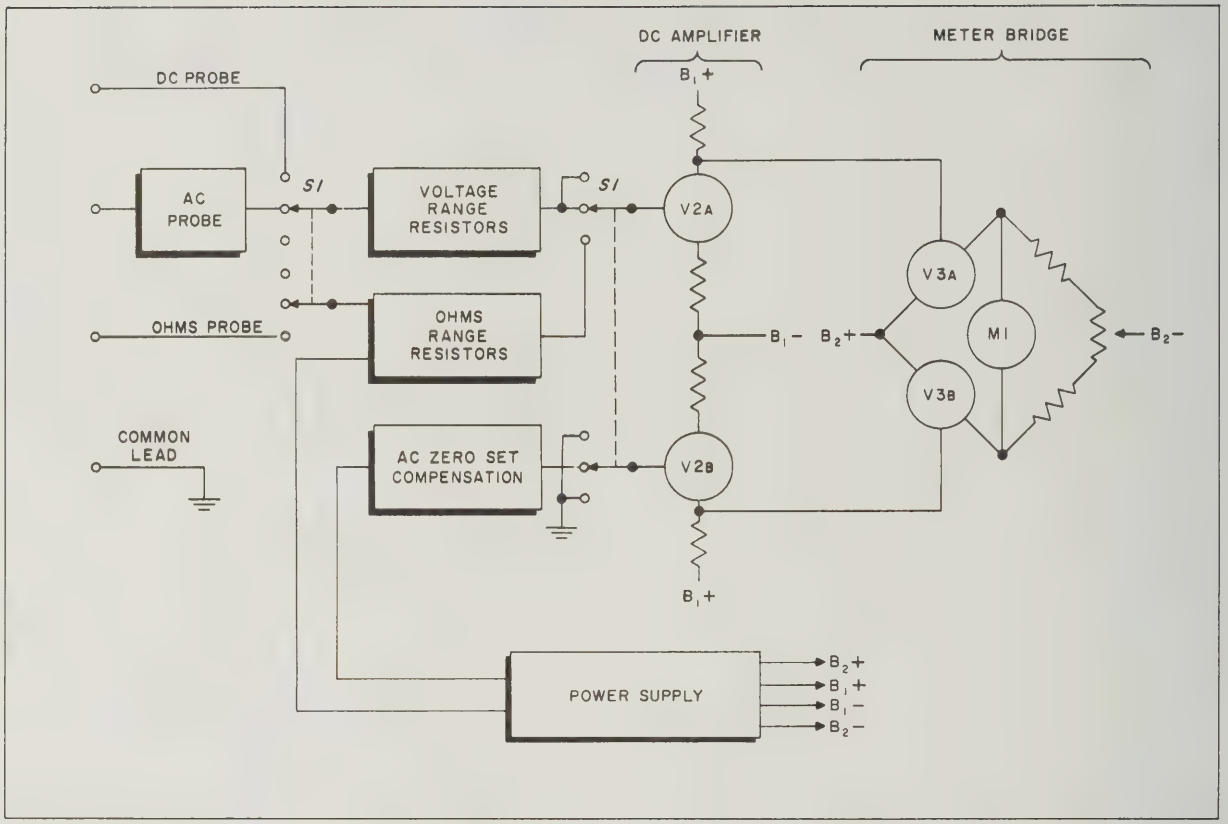


Fig. 3-1. Block Diagram of -hp- Model 410B

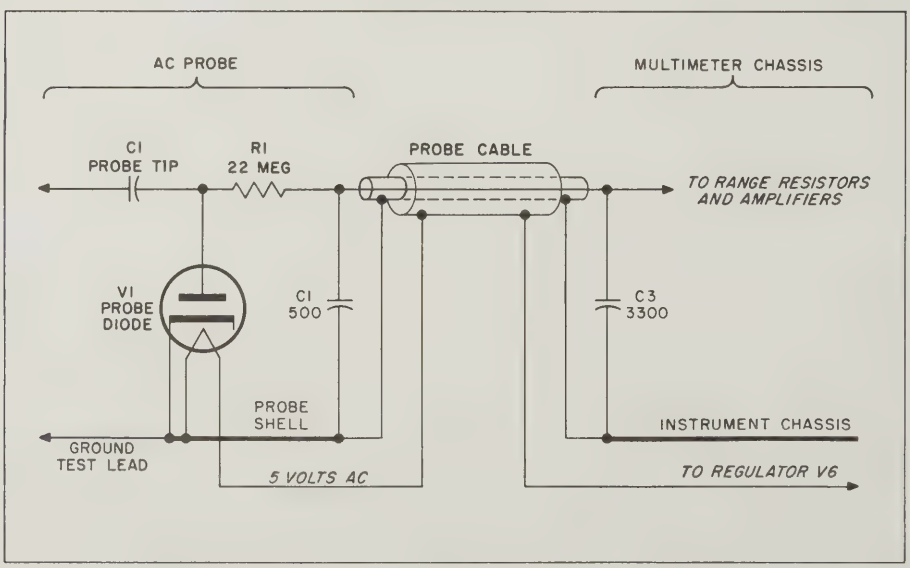


Fig. 3-2. Schematic Diagram of AC Probe

This arrangement permits short lead lengths for the actual a-c portion of the measuring circuit so that residual inductances will be minimized.

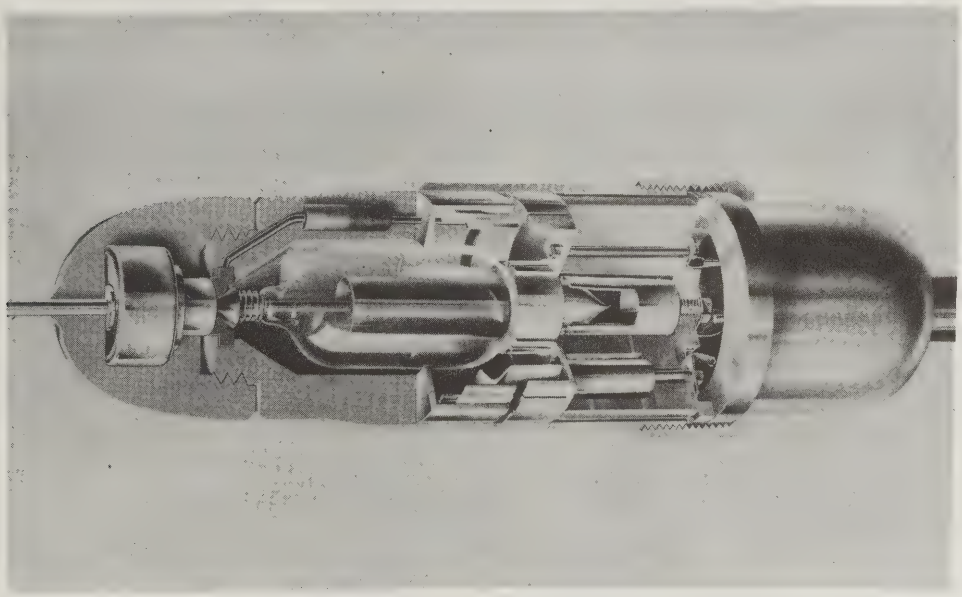


Fig. 3-3. Cutaway View of High-Frequency Probe

A cutaway view of the a-c probe showing the input blocking capacitor, rectifier diode, and RC filter is shown in Fig. 3-3. The input capacitor is molded in a removable probe tip for applications where even the small lead length of the tip should be minimized. The diode is specially designed to have plane rather than circular geometry. This type of construction has been used in order to reduce the physical length of the diode and to achieve a diode having extremely low anode-cathode capacity. The construction is such that the probe has an input capacity of only about 1.5 mmf, about 1.3 of which is the anode-cathode capacity of the diode. To achieve short transit time for the diode, the anode-cathode spacing has been maintained at only .003 inch. Reliable r-f grounding of the diode cathode is obtained by use of a large area contact ring in the special socket for the diode. Fig. 3-4 shows a line drawing of the probe diode.

The capacity in the RC filter is divided into two parts. A small 500 mmf capacitor, C2, is built into the probe near the base of the diode. At high frequencies this capacitor in combination with the 22-megohm filter resistor gives sufficient filtering so that the inductance of the flexible cable is of no consequence. For lower frequency filtering, C3, a 3300 mmf capacitor, is connected at the end of the cable inside the multimeter housing.

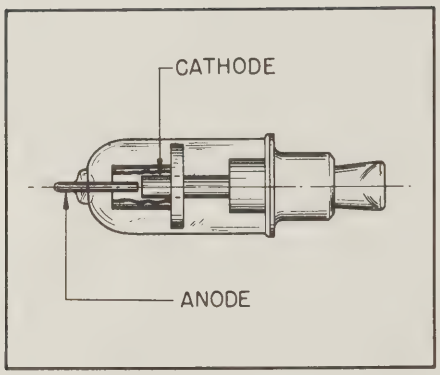


Fig. 3-4. Actual Size Drawing of High-Frequency Diode

The probe is constructed from molded polystyrene to offer a low dielectric loss which, together with the low input capacity, makes the probe a high impedance device. The input impedance of the probe as a function of frequency is given in Fig. 1-3.

The flexible cable connecting the probe to the voltmeter is a double-shielded single conductor cable. The outside shield carries a-c power for the diode heater; the inner lead carries the d-c voltage from the RC filter to the voltmeter. Ground return is made through the inner shield.

3-3. RANGE EXTENDING RESISTORS

To extend the voltage range over which both a-c and d-c measurements can be made, a precision voltage divider is connected to the input of the d-c amplifier. The taps on the divider are arranged so that the input to the amplifier does not exceed approximately .85 volt for a full-scale reading on d-c voltage measurements. On a-c measurements approximately 1.17 volt is applied to the amplifier for a full-scale reading. This increased voltage on a-c measurements is compensated by resistors in series with the indicating meter, as described later.

The precision voltage divider is made up of high-stability deposited carbon type resistors mounted on a seven-position rotary switch which serves as the range switch for the instrument.

3-4. DC AMPLIFIER

The taps on the precision voltage divider connect through the range switch to one input of the differential voltage amplifier. The amplifier consists of the two halves of a 12AU7 twin triode. The principle purpose of this amplifier is to serve as an impedance trans-

former between the 100-megohm impedance level in the range switch and the meter circuits. To achieve a high input impedance for the amplifier, it is operated without a grid resistor other than the 100-megohm voltage divider and at a low plate current in the order of a couple of microamperes. Gas current effects in the high grid impedance are minimized by operating the amplifier tubes at a reduced heater voltage and a low plate voltage (approximately 20 volts). Very large cathode resistances are used to enhance the stability of the amplifier.

For a-c measurements the second or "balance" input to the differential amplifier is connected to a source of small d-c voltage in the power supply circuit. This arrangement is designed to compensate the voltmeter for "emission voltages" that occur in the probe diode. Because of the high thermal level of the probe diode cathode, electrons are emitted by the cathode even though no signal voltage is applied to the diode anode. Some of these electrons travel to the anode and raise its potential by a few volts, enough to mask small signal voltages applied to the diode.

To compensate for this effect, the d-c voltage applied to the second input of the d-c amplifier is adjusted to be equal to the emission voltage of the diode. A voltage divider in the balance channel divides the compensating voltage in the same proportion as the input range switch divides the emission voltage so that the amplifier will always be compensated when the a-c probe is connected. The AC zero set control on the front panel adjusts the compensating voltage to exactly balance the voltage produced by the diode thereby bringing the meter to zero.

For d-c measurements the second input to the differential amplifier is grounded and serves only to supply a d-c level to balance the bridge.

3-5. METER CIRCUIT

The double-ended output of the differential amplifier is applied to a bridge circuit across which is connected the indicating meter, as illustrated by the diagram in Fig. 3-5. Two arms of the bridge are triode tubes whose grids are connected to the two sides of the differential amplifier. With no voltage being measured, the two triodes have equal grid potentials and the bridge is in a balanced state. The front panel ZERO SET control R19a, a potentiometer located between the two legs of the bridge and the d-c supply voltage, establishes the exact electrical balance of the bridge for all types of operation. Potentiometer R32 is connected in series with the meter to adjust the sensitivity of the meter circuit to the precise required value.

To permit measurement of either positive or negative d-c voltages without reversal of the test leads the SELECTOR switch reverses

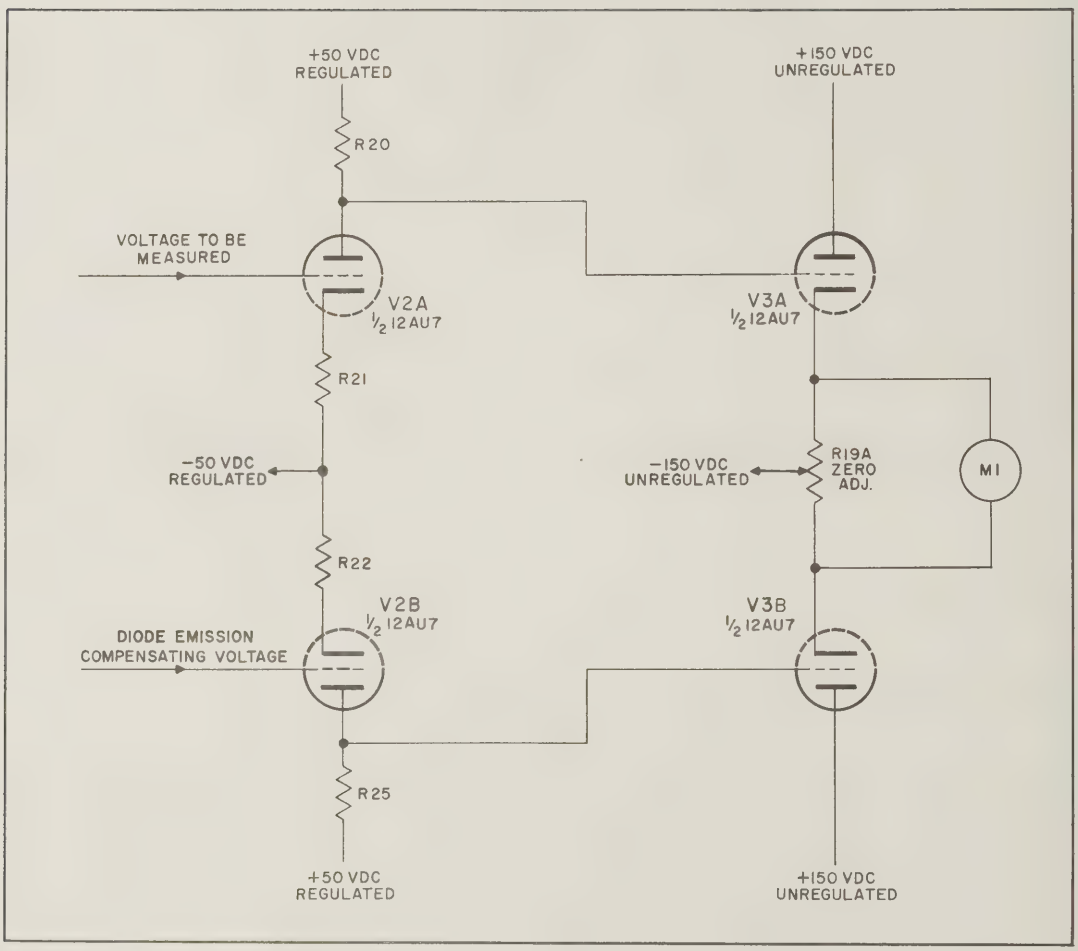


Fig. 3-5. Basic DC Amplifier Circuit

the meter within the bridge so that an up-scale reading is obtained with either polarity.

For a-c measurements the range switch of the voltmeter connects in series with the meter additional current-reducing resistors (R35 through R40) to reduce the meter current by approximately 30% so that the same meter scales can be used for the a-c and d-c ranges. For the one and three volt a-c ranges, however, it is necessary to use special meter scales because the probe diode operation at low voltages is non-linear.

For resistance measurements the SELECTOR switch connects the meter in series with the front panel OHMS ADJ. ∞ control which adjusts the sensitivity of the meter to obtain a precise full-scale indication before making a measurement.

3-6. RESISTANCE MEASUREMENT

When the multimeter is to be used to measure resistance, the range switch connects an additional set of precision resistors to the input of the d-c amplifier as shown in the block diagram in Fig. 3-1. A small, stable voltage of about 1.2 volts is taken from the regulated power supply and applied through a precision resistance to the input of the d-c amplifier thereby causing full-scale deflection of the meter. The resistance to be measured is then connected between the input of the d-c amplifier and ground. This resistance thus completes a voltage divider and reduces the voltage applied to the amplifier, bringing the meter reading down-scale. The range switch of the multimeter connects appropriate values of precision resistors into the ohmmeter circuit to extend the resistance-measuring range.

3-7. POWER SUPPLY

The power supply circuit includes a full-wave rectifier with an RC filter at the output of the filter. An 0B2 105-volt regulator tube provides regulated d-c voltage for operation of the differential d-c amplifier, ohmmeter circuits, and diode compensating circuits. D-c power for operating the bridge is obtained directly from the rectified output of the power supply. A regulated heater voltage of 5 volts a-c is also provided for the probe diode, regulation being obtained through the use of the series current-limiting resistor V6. Potentiometer R50 shunting the diode heater is used to adjust the voltage across the heater to 5 volts. A small resistor is connected in series with the heater of V2 to operate this heater on approximately 4-1/2 volts. The heater winding also supplies a voltage which is rectified by a metallic rectifier for the RX1 resistance OHMS range only. This voltage is adjusted to approximately 1.2 volt by R49 to obtain full-scale deflection on the RX1 range consistent with that on the RX10 range.

The power transformer for the multimeter is equipped with two primary windings so that the instrument may be connected for operation on either 115 or 230 volt power. The windings are connected in parallel for use with 115 volts, and in series for 230 volts. For proper phasing of the windings the terminals on the transformer are numbered and wired as shown on the schematic diagram for the multimeter.

SECTION IV

MAINTENANCE

4-1. INTRODUCTORY

No routine maintenance procedures are required for the -hp- Model 410B. When replacing any of the tubes in the equipment, however, it is desirable to check the accuracy of the multimeter. To do this it is necessary to have a precision d-c voltmeter and a precision a-c voltmeter, preferably of the dynamometer type. The accuracy of these instruments should be within 1-2%, because the basic accuracy of the 410B is within 3%. The procedures to follow in checking and adjusting the calibration of the instrument are described in paragraphs 4-4 and 4-5.

If a tube failure occurs after an extended period of use such as 1000 hours of operating time, it is desirable to replace all tubes at that time, to avoid need for more frequent recalibration than necessary.

A trouble-shooting chart listing possible operating troubles is included at the end of this section.

4-2. TUBE REPLACEMENT

Replacing V1 (Figure 4-1)

When replacing probe diode V1, some change in a-c voltage-measuring accuracy may occur on the lower three a-c measuring ranges of the instrument. In a typical case these changes will be less than 2%. With some diodes the changes can be greater than this, however, so it is desirable to recheck calibration accuracy.

The quality of the individual replacement diode will also effect the high frequency accuracy of the instrument. However, specialized equipment is necessary for checking the high frequency accuracy. If high frequency errors are suspected with a new diode installed, it is recommended that another replacement diode be tried.

When probe diode V1 is replaced, the filament voltage on V1 should be checked. A convenient way to measure this voltage is to loosen the rear of the probe to expose the cable connections (see Fig. 4-1 for exploded view of probe) and to connect a wire from the probe nose contact to the outer shield of the probe cable at the back of the probe, making certain that the probe is otherwise properly assembled so that all contacts are made. This will permit the voltmeter to read its own filament voltage. The filament voltage should be 5.0 volt rms and can be adjusted as necessary by R50, available when the rear cover is removed.

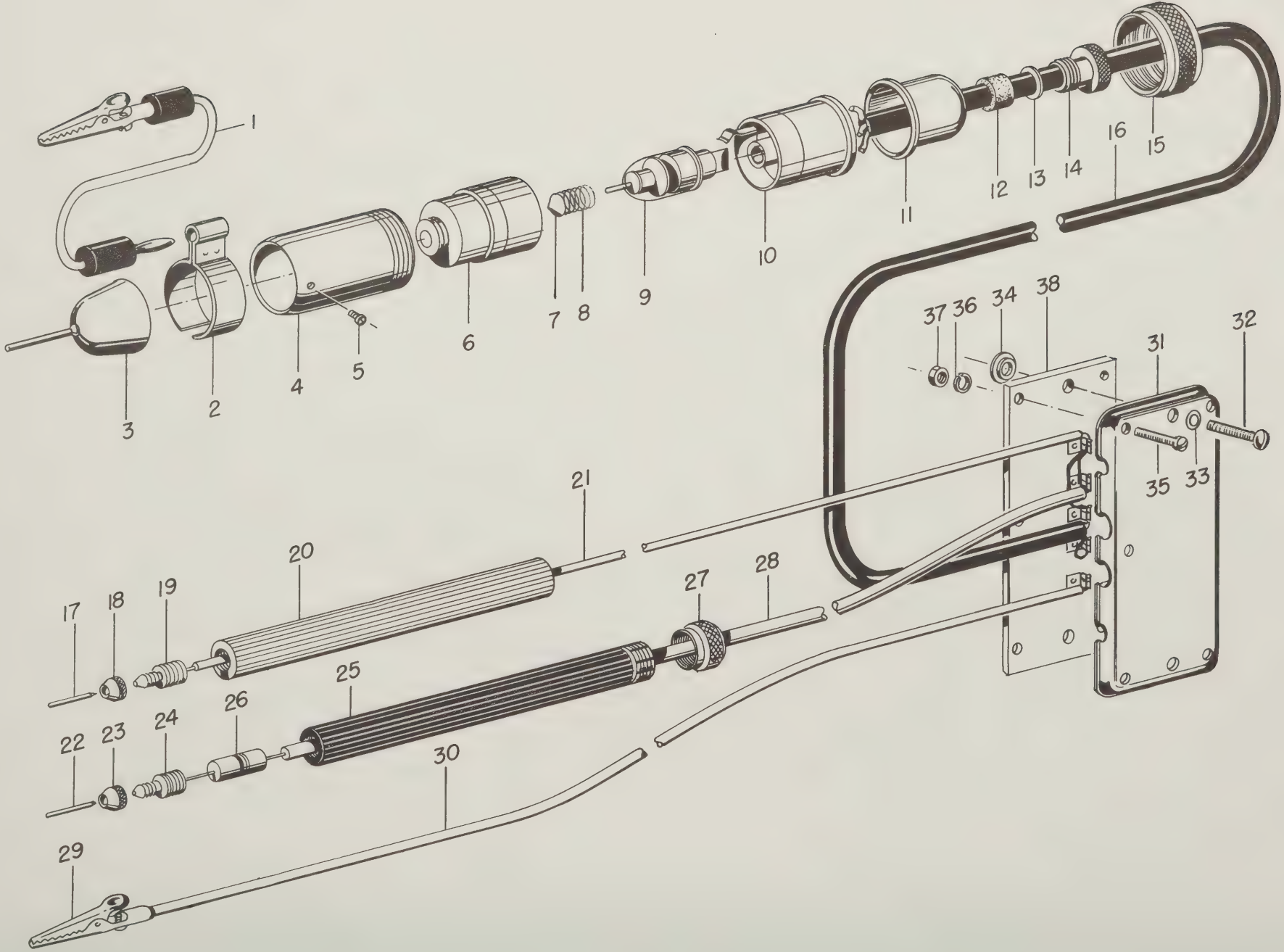


Fig. 4-1. Test Probe Assembly, Including Exploded View of AC Probe (-hp- Stock # 410B-16)

Replacement of V2 and V3

When V2 or V3 are replaced, three checks should be made:

a) amplifier balance
b) microphonics
c) voltage calibration

Checking the balance of the amplifier can be done merely by making certain that the instrument zero sets with the new tube installed. Checking for microphonics consists of making certain that the new tube is not unduly sensitive to vibration of the instrument case.

The calibration procedure to be followed after replacement of V2 or V3 is described in paragraph 4-4.

4-3. REPLACEMENT OF BALLAST TUBE V6

V6 is a current-regulating resistance element enclosed in a glass envelope. Its purpose is to maintain a constant voltage of 5 volts rms on the a-c heater for probe diode V1. Failure of V6 is usually caused by overloading due to shorts. For this reason, before installing a new ballast tube V6, it is recommended that the resistance between pin 7 of V6 and ground be checked with V6 removed. A resistance value of less than approximately 4 ohms indicates possibility of at least a partial short.

If the resistance value is in the range from 4 to 6 ohms, it is ordinarily safe to install the new ballast tube. After installing, measure the a-c voltage between pin 7 of V6 and ground, or as described in paragraph 4-2. If necessary, adjust R50 so that this voltage will be 5.0 volts rms.

4-4. BASIC VOLTAGE CALIBRATION

Before attempting to adjust either the a-c calibration accuracy or the ohmmeter calibration accuracy, it is necessary that the calibration of the d-c measuring circuits be accurate. Checking the d-c calibration accuracy is also recommended after replacing V2 or V3. The procedure is as follows:

a) Connect multimeter to a 115-volt power source and allow to heat for at least 15 minutes. It is desirable that the line voltage be accurately adjusted to 115 volts or to the predominating line voltage value if that value is somewhat less or more than 115 volts. The power transformer in the equipment is also designed to accommodate 230 volt lines; if the equipment is operated from 230 volt lines, the above information should be modified accordingly.

b) Remove the back cover from the instrument. To remove the cover push down the button at the top rear of the cabinet and slide back cover off.

c) Zero set the instrument with the RANGE switch set to the 1 volt range and the SELECTOR switch set to the + and - positions as described in paragraph 2-5.

d) Set SELECTOR switch to +. Range switch should remain at 1 volt.

e) Apply exactly 1 volt d-c to the d-c test leads. This 1 volt value can be obtained using a battery and potentiometer arrangement. The voltage applied to the voltmeter should be monitored and adjusted using the precision d-c meter described earlier. With exactly 1 volt applied to the multimeter the meter pointer should indicate an exact full-scale reading on the uppermost scale. If necessary, adjust R32 through the back of the instrument to make the meter read exactly full-scale. R32 is identified in Fig. 4-2 and by appropriate markings on the back of the instrument.

f) The calibration of the remaining d-c ranges should now be checked insofar as the external precision meter and d-c source will permit. No adjustment circuits are provided, however, for the remaining d-c ranges. The accuracy of these ranges is determined by the values of the precision range switch resistors R3 through R9. A gross inaccuracy in any of the remaining d-c ranges indicates an incorrect range resistor or resistors.

g) Check a-c calibration accuracy as described below.

4-5. AC VOLTAGE CALIBRATION

The accuracy of the a-c voltage ranges of the multimeter should be checked after the probe diode V1 has been replaced. Before checking the a-c ranges, it is desirable to adjust the basic d-c voltage calibration as described above in paragraph 4-4. The procedure for checking and adjusting the a-c calibration is as follows:

a) Adjust line voltage as described in step a of paragraph 4-4 above; remove back cover as described in step b of the same paragraph.

b) Set SELECTOR switch to a-c and RANGE switch to 1V position. Allow equipment to heat for at least 15 minutes with these switch settings.

c) Zero set the d-c and a-c circuits in that order with the RANGE switch still at the 1V position, but changing the SELECTOR switch as necessary.

d) Apply to the a-c probe a voltage of exactly 1 volt rms. This voltage should have an accurate, undistorted sine waveform. The frequency of this voltage should preferably be 100 cps or higher if permitted by the frequency characteristic of the dynamometer voltmeter. A good voltage source for this purpose is an accurate audio oscillator such as the -hp- Model 200AB, 205AG, etc. To determine that the voltage applied to the probe is accurate, it should be monitored by the precision dynamometer type voltmeter.

e) With exactly 1 volt rms applied to the probe, the voltmeter should indicate exactly full-scale on the 1 volt a-c (red) meter scale. If not, adjust R35 (available through back of instrument).

f) Set the RANGE selector to the 3-volt range. Increase voltage applied to probe to exactly 3 volts rms. Adjust potentiometer R39 to obtain accurate full-scale reading on the 3 volt a-c (red) meter scale.

g) Calibrate the remaining a-c ranges, reading the 1 and 3 volt d-c (black) scales of the meter. The following chart shows the adjusting potentiometers for each of the a-c ranges.

RANGE Switch Setting	Calibrating Voltage	Adjustment Resistor
1V	1V RMS	R35
3V	3V RMS	R39
10V	10V RMS	R40
30V	30V RMS	R36
100V	100V RMS	R37
300V	300V RMS	R38

4-6. OHMMETER ADJUSTMENTS

No internal adjustments are provided for the ohmmeter circuits other than for the full-scale setting of the RX1 range. The full-scale setting of the RX1 range may begin to differ from that of the other ranges as selenium rectifier CR1 ages. To adjust the full-scale setting of the RX1 range to be equal to the full-scale setting of the other ranges, proceed as follows:

a) Connect multimeter to power line and allow to warm up. Normally the multimeter should be operated from 115 volts; however, if it is to be operated at line voltages substantially higher or lower than 115 volts the adjustment may be made at the expected line voltage.

b) Zero set the instrument as described in paragraph 2-5.

c) Set RANGE switch to RX10 range and adjust OHM ADJ.∞ for exact full-scale meter reading.

d) Set RANGE switch to RX1 range.

e) If meter pointer does not read exactly full-scale (∞), remove back panel from multimeter case and adjust R49 as necessary.

MODEL 410B

TROUBLE SHOOTING CHART

SYMPTOM	CAUSE OF TROUBLE	REMEDY AND CHECKS
AC power cord plugged in, instrument turned on, pilot light does not light and no readings obtained.	Defective power cord, plug, or receptacle. Fuse (F1) blown. Defective a-c switch.	Check power source and connections. Check fuse (F1) and rectifier tube V5. Check power switch continuity.
No readings obtainable, no zero adjustment, pilot lamp lights.	Defective tubes V2, V3, or V5.	Check V2, V3, and V5, if necessary, replace and recalibrate, see paragraph 4-2.
Zero set drifts or zero set not possible.	Defective tubes V2 and V3.	Check tubes V2 and V3, replace and recalibrate, see paragraph 4-2.
No a-c readings, d-c readings normal.	Probe cap loose, defective V1 or V6.	Tighten probe cap. Check V1 for operation.
A-c zero set drifts or inaccurate a-c readings only on all ranges.	Defective V1.	Replace V1 and recalibrate as instructed in paragraph 4-3.
A-c zero set not possible.	Outside shield of a-c probe cable shorted to ground.	Check cable and repair short.
Inaccurate d-c and a-c readings.	Defective V2 or V3, defective range resistor (R3 through R9), misadjustment of R31.	Check V2 and V3 or R3 through R9, readjust R31 as instructed in paragraph 4-2.
Erroneous resistance readings following use of OHMS probe on high d-c voltage.	Burned resistors R10 through R13.	Check resistors R10 through R13 and if necessary, replace burned resistor.

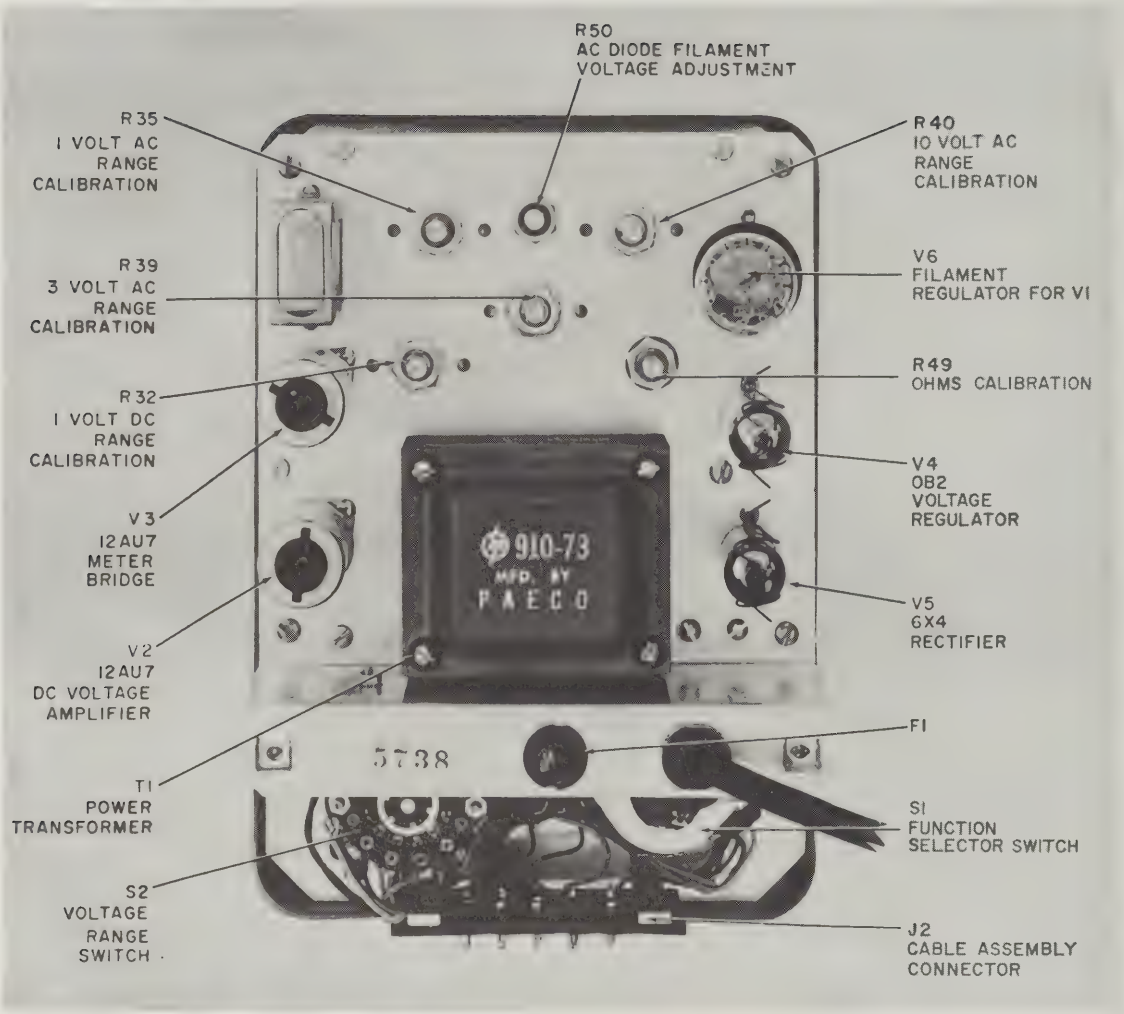


Fig. 4-2. Rear View of Model 410B, Chassis Removed from Instrument Case

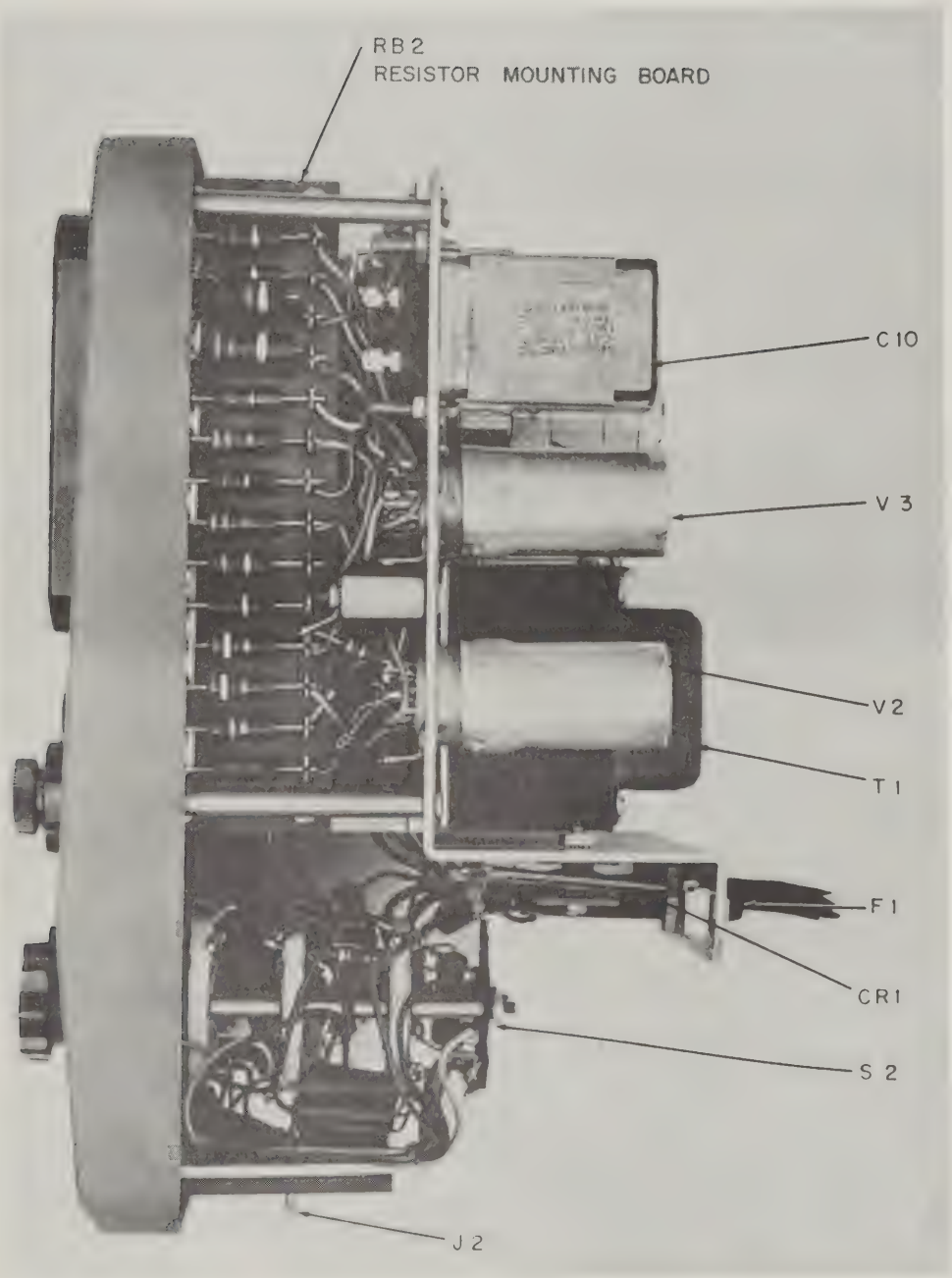


Fig. 4-3. Right Side View of Model 410B

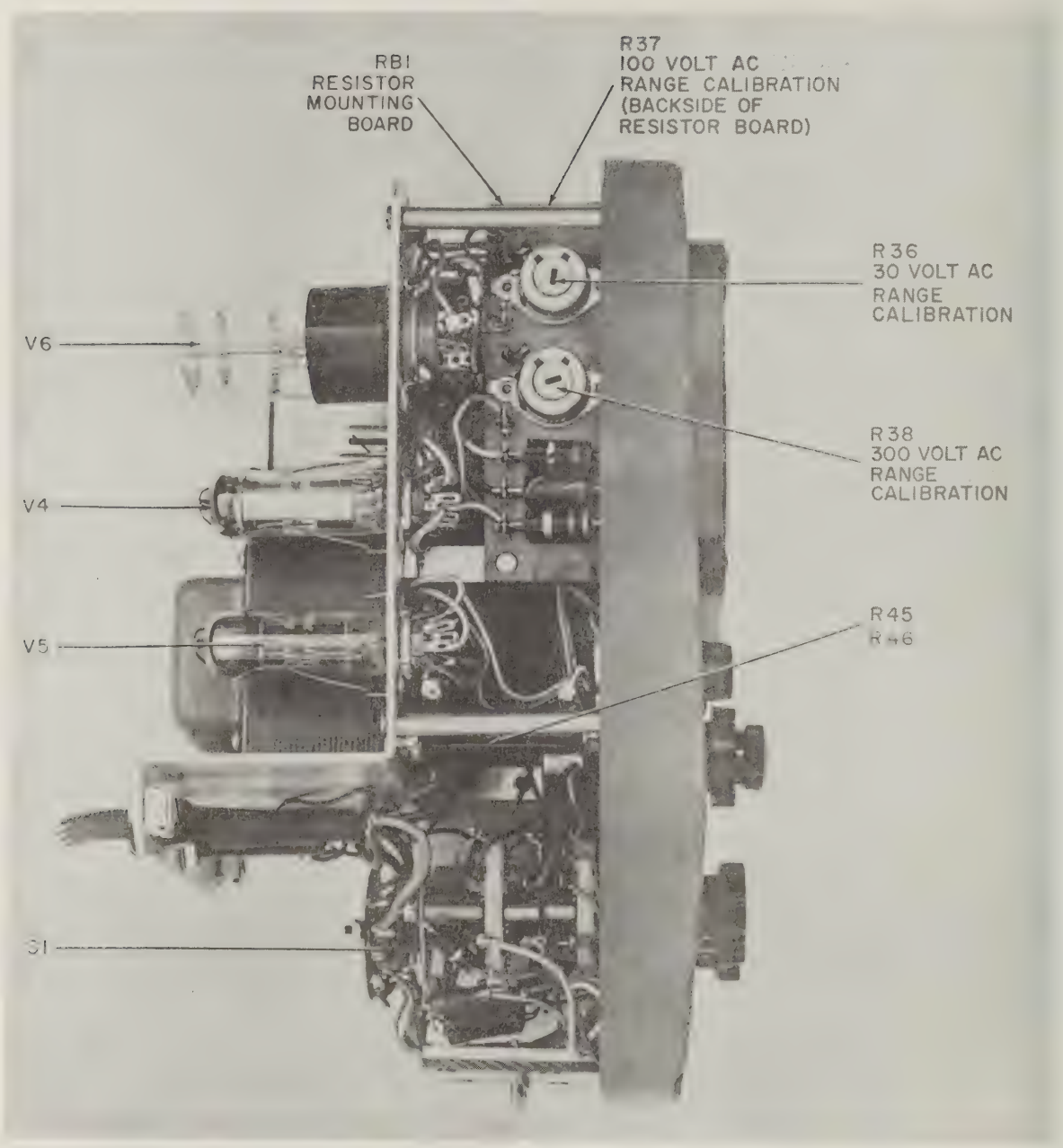


Fig. 4-4. Left Side View of Model 410B

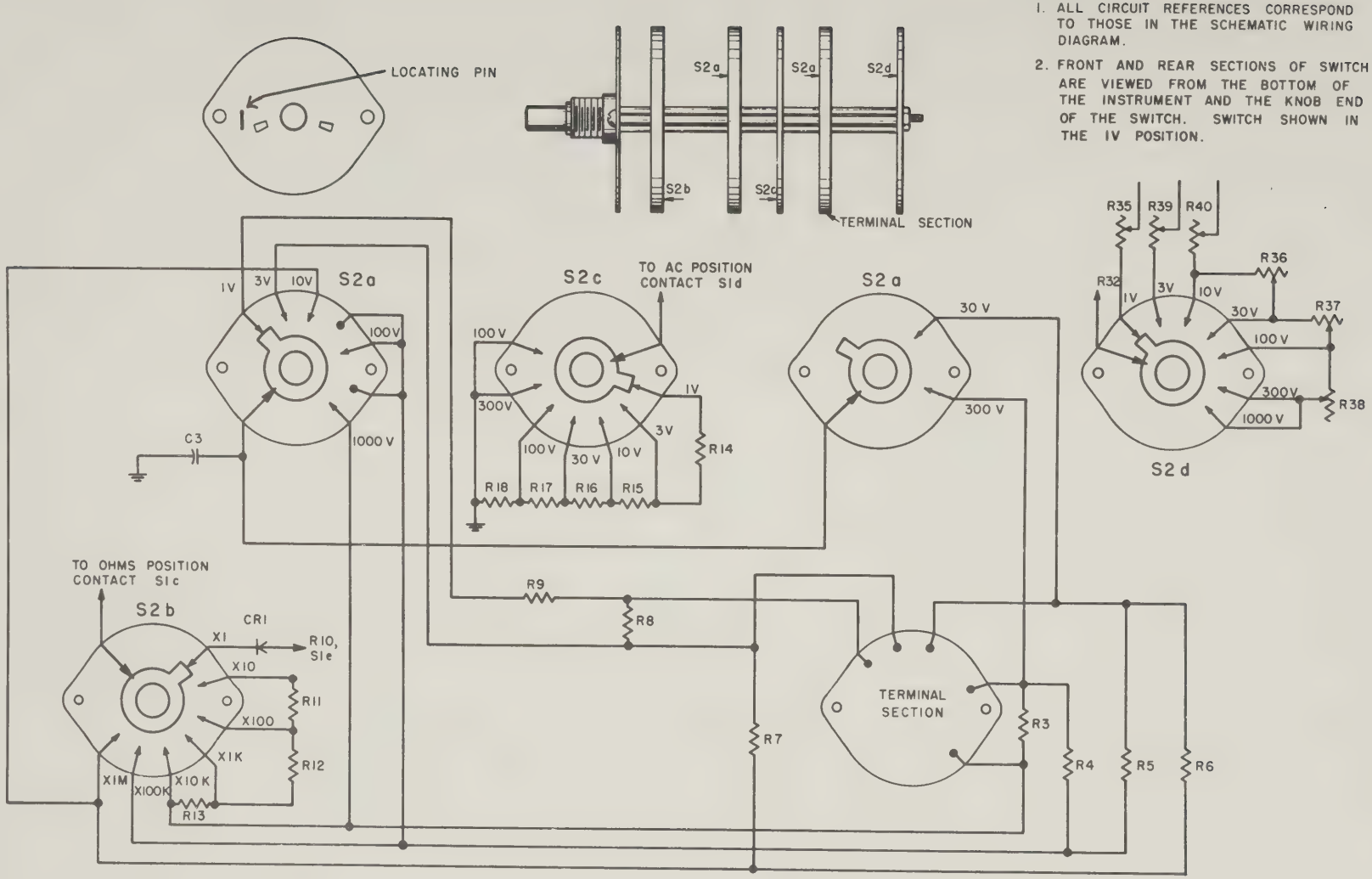


Fig. 4-5. Range Switch Details, Model 410B

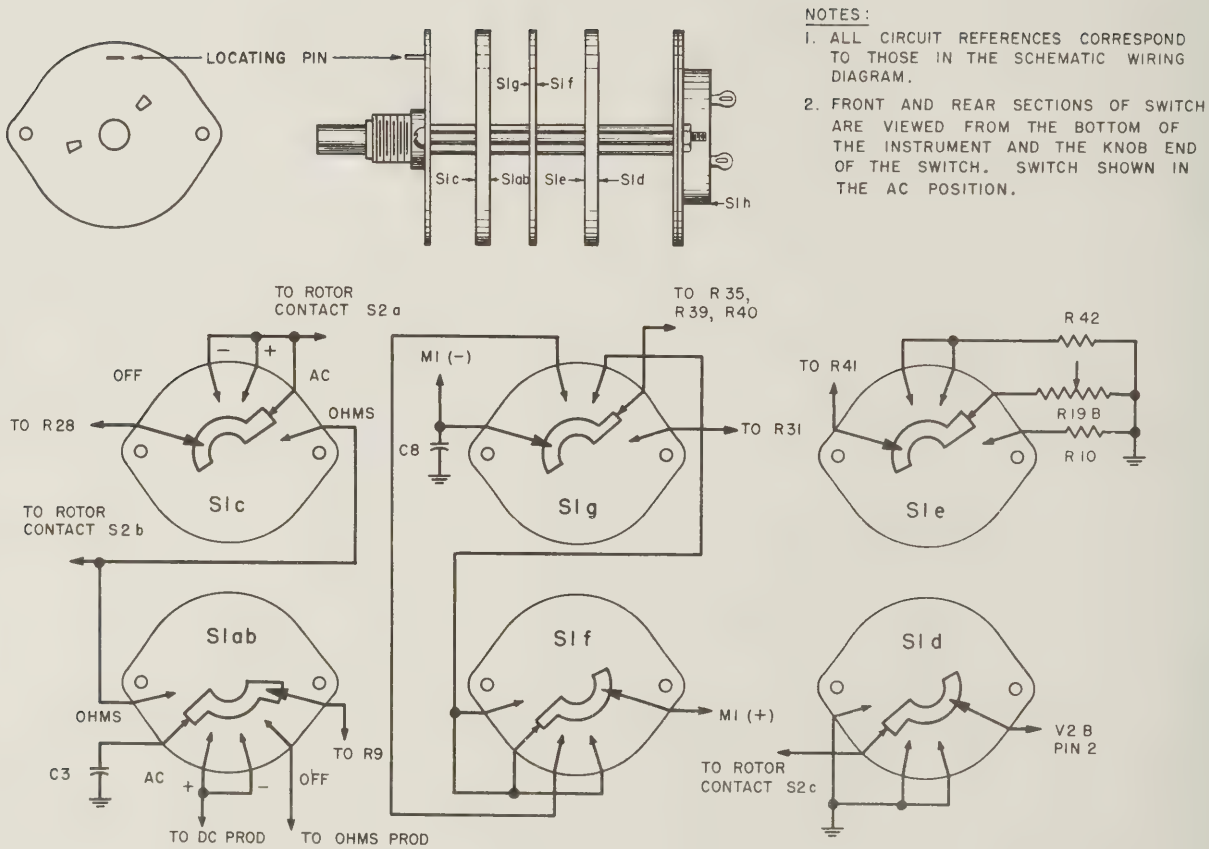
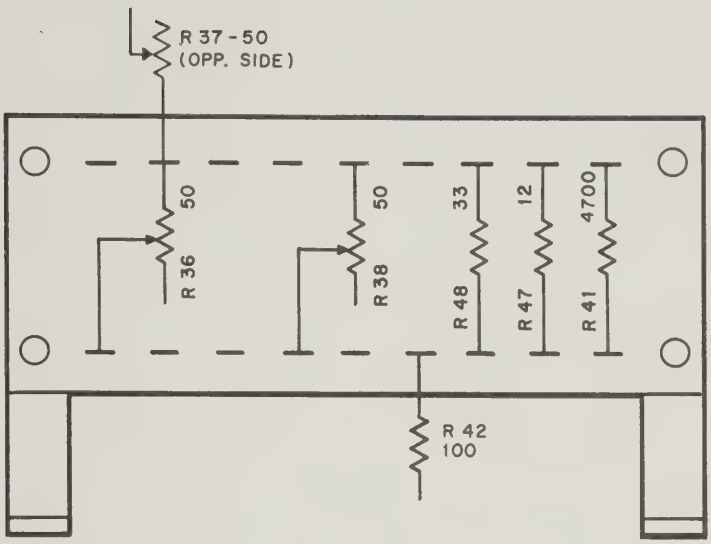


Fig. 4-6. Selector Switch Details, Model 410B



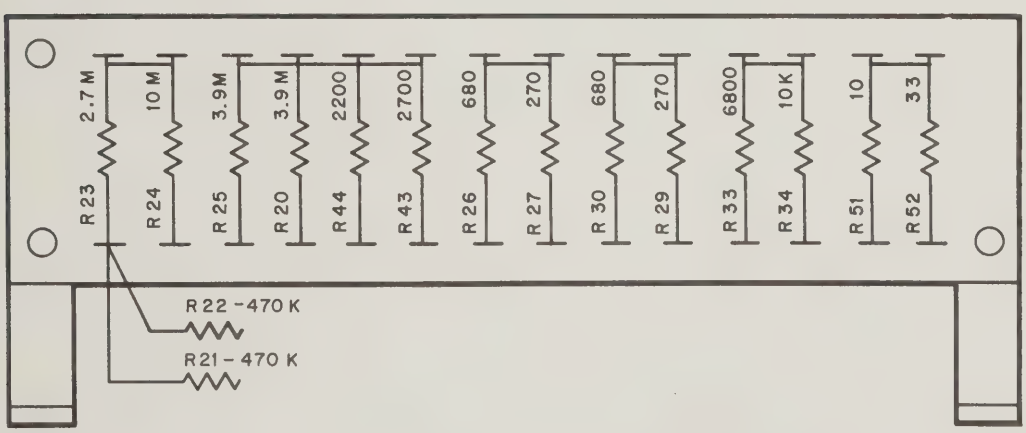
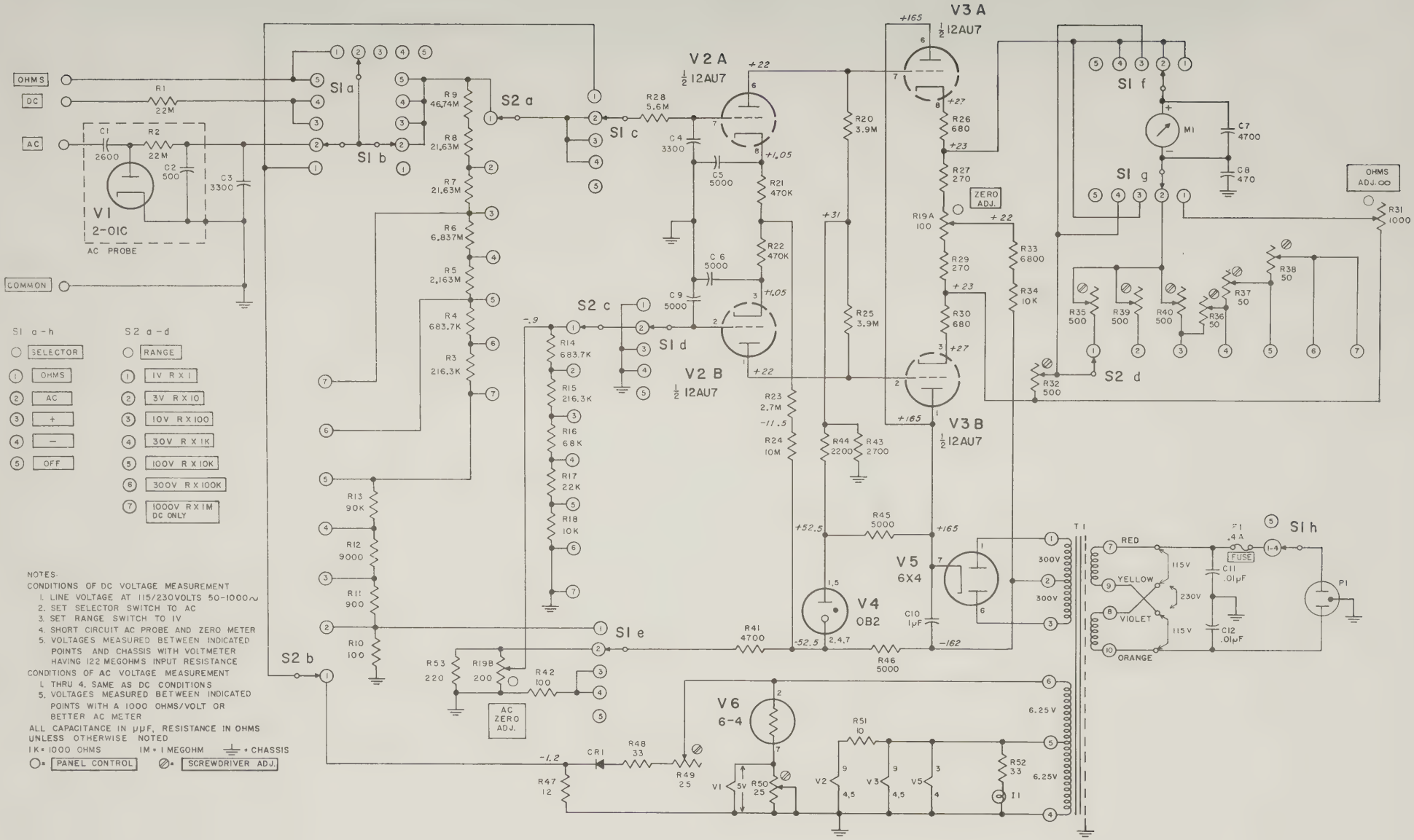


Fig. 4-7. Resistor Board Details, Model 410B



SCHEMATIC DIAGRAM OF MODEL 410B

SERIAL 8355 & ABOVE

SECTION V

TABLE OF REPLACEABLE PARTS

NOTE

Any changes in the Table of Replaceable Parts will be listed on a Production Change sheet at the front of this manual.

When ordering parts from the factory always include the following information:

Instrument model number
Serial number
-hp- stock number of part
Description of part

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
C1, C2	Capacitor: Part of AC probe		
C3	Capacitor: fixed, mica, 3300 μf, ±10%, 500 vdcw	14-64	V Type W
C4	Capacitor: fixed, mica, 3300 μf, ±10%, 500 vdcw	14-64	V Type W
C5	Capacitor: fixed, ceramic, 5000 μf, 500 vdcw	15-47	K Type BPD-5
C6	Capacitor: fixed, ceramic, 5000 μf, 500 vdcw	15-47	K Type BPD-5
C7	Capacitor: fixed, mica, 4700 μf, ±10%, 300 vdcw	14-44	Z C-1247
C8	Capacitor: fixed, mica, 470 μμf, ±10%, 500 vdcw	14-62	V Type OXM
C9	Capacitor: fixed, ceramic, 5000 μf, 500 vdcw	15-47	K Type BPD-5
C10	Capacitor: fixed, oil filled paper, 1 μf, ±10%, 600 vdcw	17-12	N #23F467G103
C11	Capacitor: fixed, paper, .01 μf, ±10%, 1600 vdcw	16-56	CC #73P103916
C12	Capacitor: fixed, paper, .01 μf, ±10%, 1600 vdcw	16-56	CC #73P103916
C13	Capacitor: fixed, electrolytic, 50 μf, 50 vdcw This part may be omitted	18-50	X TC-39
R1	Resistor: fixed, composition, 22 megohms, ±10%, 1 W Part of Cable Assembly (DC Probe)	24-22M	B GB 2261
R2	Resistor: Part of AC probe		
R3	Resistor: fixed, composition, 216, 300 ohms, ±1%, 1 W	31-216.3K	HP
R4	Resistor: fixed, composition, 683, 700 ohms, ±1%, 1 W	31-683.7K	HP
R5	Resistor: fixed, composition, 2.163 megohms, ±1%, 1 W	31-2.163M	HP

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R6	Resistor: fixed, compositon, 6.837 megohms, ±1%, 1 W	31-6.837M	HP
R7	Resistor: fixed, composition, 21.63 megohms, ±1%, 2 W	32-21.63M	HP
R8	Resistor: fixed, composition, 21.63 megohms, ±1%, 2 W	32-21.63M	HP
R9	Resistor: fixed, composition, 46.74 megohms, ±1%, 2 W	32-46.74M	HP
R10	Resistor: fixed, composition, 100 ohms, ±1%, 1/2 W	33-100	HP
R11	Resistor: fixed, composition, 900 ohms, ±1%, 1/2 W	33-900	HP
R12	Resistor: fixed, composition, 9000 ohms, ±1%, 1/2 W	33-9K	HP
R13	Resistor: fixed, composition, 90,000 ohms, ±1%, 1/2 W	33-90K	HP
R14	Resistor: fixed, composition, 683,700 ohms, ±1%, 1 W	33-683.7K	HP
R15	Resistor: fixed, composition, 216,300 ohms, ±1%, 1/2 W	33-216.3K	HP
R16	Resistor: fixed, composition, 68,000 ohms, ±10%, 1/2 W	23-68K	B EB 6831
R17	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2 W	23-22K	B EB 2231
R18	Resistor: fixed, composition, 10,000 ohms, ±10%, 1/2 W	23-10K	B EB 1031
R19	Resistor: variable, wirewound, 2 sections, front 100 ohms rear 200 ohms, linear taper	210-69	I CM-8602
R20	Resistor: fixed, composition, 3.9 megohms, ±5%, 1 W	24-3.9M-5	B GB 3955
R21	Resistor: fixed, composition, 470,000 ohms, ±5%, 1/2 W	23-470K-5	B EB 4745
R22	Resistor: fixed, composition, 470,000 ohms, ±5%, 1/2 W	23-470K-5	B EB 4745

*See "List of Manufacturers Code Letters For Replaceable Parts Table "

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R23	Resistor: fixed, composition, 2.7 megohms, ±5%, 1 W	24-2.7M-5	B GB 2755
R24	Resistor: fixed, composition, 10 megohms, ±5%, 1 W	24-10M-5	B GB 1065
R25	Resistor: fixed, composition, 3.9 megohms, ±5%, 1 W	24-3.9M-5	B GB 3955
R26	Resistor: fixed, composition, 680 ohms, ±5%, 1 W	24-680-5	B GB 6815
R27	Resistor: fixed, composition, 270 ohms, ±5%, 1 W	24-270-5	B GB 2715
R28	Resistor: fixed, composition, 5.6 megohms, ±10%, 1/2 W	23-5.6M	B EB 5651
R29	Resistor: fixed, composition, 270 ohms, ±5%, 1 W	24-270-5	B GB 2715
R30	Resistor: fixed, composition, 680 ohms, ±5%, 1 W	24-680-5	B GB 6815
R31	Resistor: variable, wirewound, 1000 ohms, linear taper	210-5	G #27-010-355
R32	Resistor: variable, wirewound, 500 ohms, linear taper	210-73	I Type 43
R33	Resistor: fixed, composition, 6800 ohms, ±10%, 2 W	25-6800	B HB 6821
R34	Resistor: fixed, composition, 10,000 ohms, ±10%, 2 W	25-10K	B HB 1031
R35	Resistor: variable, wirewound, 500 ohms, linear taper	210-73	I Type 43
R36	Resistor: variable, wirewound, 50 ohms, linear taper	210-27	Muter #10508
R37	Resistor: variable, wirewound, 50 ohms, linear taper	210-27	Muter #10508
R38	Resistor: variable, wirewound, 50 ohms, linear taper	210-27	Muter #10508
R39	Resistor: variable, wirewound, 500 ohms, linear taper	210-73	I Type 43
R40	Resistor: variable, wirewound, 500 ohms, linear taper	210-73	I Type 43

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
R41	Resistor: fixed, composition 4700 ohms, ±10%, 2 W	25-4700	B HB 4721
R42	Resistor: fixed, composition, 100 ohms, ±10%, 1 W	24-100	B GB 1011
R43	Resistor: fixed, composition, 2700 ohms, ±10%, 1 W	24-2700	B GB 2721
R44	Resistor: fixed, composition, 2200 ohms, ±10%, 1 W	24-2200	B GB 2231
R45	Resistor: fixed, wirewound, 5000 ohms, ±10%, 10 W	26-8	S Type 1-3/4E
R46	Resistor: fixed, wirewound, 5000 ohms, ±10%, 10 W	26-8	S Type 1-3/4E
R47	Resistor: fixed, wirewound, 12 ohms	410B-26	HP
R48	Resistor: fixed, composition, 33 ohms, ±10%, 2 W	25-33	B HB 3301
R49	Resistor: variable, wirewound, 25 ohms, ±10%, linear taper	210-46	Precision Parts Co., #MP 25
R50	Resistor: variable, wirewound, 25 ohms, ±10%, linear taper	210-46	Precision Parts Co., #MP 25
R51	Resistor: fixed, composition, 10 ohms, ±10%, 1 W	24-10	B GB 1001
R52	Resistor: fixed, composition, 33 ohms, ±10%, 1 W	24-33	B GB 3301
R53	Resistor: fixed, composition, 220 ohms, ±10%, 1 W	24-220	B GB 2211
F1	Fuse: 1A, 3 AG type (115V operation)	211-56	T, #312001
F1	Fuse: .5A, 3 AG type (230V operation)	211-36	T, #321005
	Fuseholder:	140-18	T, #342001
	Indicator Lamp Assembly:	145-2	BB, #807BS
	Knob: AC	37-17	HP
	Knob: 1-1/2" diam.	37-11	HP
	Knob: countersunk	37-16	HP
	Knob: 11/16" diam.	37-1	HP
I1	Lamp	211-47	O, Mazda #47

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
	Male Connector Board:	410B-76M	HP
M1	Meter:	112-15	HP
	The numbers shown in the circuit reference column identify the following parts on the Complete Probe Assembly drawing.		
1-38	Probe Assembly: Consists of AC probe, DC volts and ohms test prods, all test leads and female connector board. Includes resistors R1, R2 and capacitors C1, C2.	410B-16	HP
	Probe Assembly Parts that may be obtained separately:		
	DC volts Test Prod:	410B-95A	HP
	AC Probe: (less diode)	410B-95B	HP
	Common Ground Lead:	42A-95C	HP
	Ohmmeter Test Prod	42A-95D	HP
1.	Ground Clip Lead	42A-17	HP
2.	Ground Clip Sleeve	42A-25H	HP
3.	Probe Blocking Capacitor	42A-84	HP
4.	Sleeve	42A-25C	HP
5.	4-40 x 1/4" Fillister Head Mach. Screw	230-34	HP
6.	Probe Contact Plate	42A-95E	HP
7. } 8.	Contact Tip and Spring	42A-25L	HP
9.	AC Probe Diode (2-01C)	212-2-01C	HP
10.	Socket Assembly	42A-95F	HP
11.	Cap	42A-25G-1	HP
12.	Rubber Washer	89-24	HP
13.	Metal Washer	512-46	HP
14.	Clamp Nut	G57B	HP
15.	Retainer Cap	42A-25J	HP
16.	4 ft. of Special Coaxial Cable	812-35	HP
17.	Needle		
18.	Tip Nut	Supplied as a	
19.	Screw Connector	unit	149-26 HP
20.	Ohms Probe Body		
21.	4' Red Rubber Covered Wire	816-2	
22.	Needle		
23.	Tip Nut	Supplied as a	
24.	Screw Connector	unit	42A-16L HP
25.	DC Probe Body		
26.	22 Megohm, 1 watt Carbon Resistor	24-22M	HP
27.	Nut	42A-16K	HP
28.	4' Coaxial Black Cable	812-11	HP
29.	Alligator Clip	38-31	HP
30.	4' Black Wire	816-1	HP

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

TABLE OF REPLACEABLE PARTS

Circuit Ref.	Description	-hp- Stock No.	Mfr. * & Mfrs. Designation
31.	Shield	410B-55	HP
32.	6-32 x 1-1/8" Round Head Mach. Screw	236-17	HP
33.	#6 Flat Steel Washer, 9/32"	512-37	HP
34.	#6 Extruded Fiber Washer	512-13	HP
35.	4-40 x 3/4" Fillister Head Mach. Screw	222-42	HP
36.	#4 Compression Washer, 1/16"	219-20	HP
37.	4-40 x 3/16" Nut	234-1	HP
38.	Female Connector Board	410B-76F	HP
	Metallic Rectifier:	212-77	M, 4D2814AS
	Rear Cover:	410B-1C	HP
P1	Power Cable:	812-56	HP
S1 abcde fgh	Selector Switch Assembly: The following resistors and capacitors are part of this assembly but are also listed separately: R10, C7	410B-19B	HP
S2 abcd	Range Switch Assembly: The following resistors are part of this assembly but are also listed separately: R3-R9, R11, R18.	410B-19W	HP
T1	Power Transformer	910-73	HP
	Tube Holder: for 6X4, OB2 tubes	140-13	HP
	Tube Holder: for 12AU7 tubes	122-10	H, #12627
V1	Tube: 2-01C	212-46	HP
V2	Tube: 12AU7	212-12AU7	ZZ
V3	Tube: 12AU7	212-12AU7	ZZ
V4	Tube: OB2	212-OB2	ZZ
V5	Tube: 6X4	212-6X4	ZZ
V6	Ballast Tube: #6-4	211-38	C, #6-4

*See "List of Manufacturers Code Letters For Replaceable Parts Table."

LIST OF MANUFACTURERS CODE LETTERS FOR REPLACEABLE PARTS TABLE

Code Letter	Manufacturer
A	Aerovox Corp.
B	Allen-Bradley Co.
C	Amperite Co.
D	Arrow, Hart and Hegeman
E	Bussman Manufacturing Co.
F	Carborundum Co.
G	Centralab
H	Cinch Manufacturing Co.
HP	Hewlett-Packard
I	Clarostat Manufacturing Co.
J	Cornell Dubilier Electric Co.
K	Hi-Q Division of Aerovox Corp.
L	Erie Resistor Corp.
M	Federal Telephone and Radio Corp.
N	General Electric Co.
O	General Electric Supply Corp.
P	Girard-Hopkins
R	International Resistance Co.
S	Lectrohm, Inc.
T	Littelfuse, Inc.
V	Micamold Radio Corp.
X	P.R. Mallory Co., Inc.
Z	Sangamo Electric Co.
AA	Sarkes Tarzian
CC	Sprague Electric Co.
DD	Stackpole Carbon Co.
EE	Sylvania Electric Products, Inc.
FF	Western Electric Co.
HH	Amphenol
II	Dial Light Co. of America
KK	Switchcraft, Inc.
LL	Gremar Mfg. Co.
MM	Carad Corp.
ZZ	Any tube having RETMA standard characteristics

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

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- Microwave Test Equipment
- Nuclear Scalers
- Oscillators
- Power Meters
- Power Supplies
- Pulse Generators
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- Slotted Sections
- Square Wave Generators
- Standing Wave Indicators
- Time Interval Meters
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- VHF Bridge
- Video Test Oscillators
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SHORT FORM CATALOG

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HEWLETT-PACKARD

410B

HIGH FREQUENCY VACUUM TUBE VOLTMETER

SERIALS PREFIXED: 024-

OPERATING AND SERVICING MANUAL

PRINTED 6/60

OPERATING AND SERVICING MANUAL

MODEL 410B
HIGH FREQUENCY
VACUUM TUBE VOLTMETER

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SPECIFICATIONS

RANGES:	1 to 300 volts full scale in 6 ranges: 1, 3, 10, 30, 100, and 300 volts AC or DC and 0-1000 volt range DC. Resistance 0.2 ohm to 500 megohms in seven ranges. Mid-scale reading of 10, 100, 1,000, 10,000, 100,000 ohms, 1 megohm, and 10 megohms.
ACCURACY:	±3% of full scale on all ranges on sinusoidal AC voltages and DC voltages. The AC portion of the instrument is a peak-reading device, calibrated in rms volts. Ohmmeter accuracy is ±1 ohm at mid-scale of RX1 range, ±5% at mid-scale of all other ranges.
FREQUENCY RESPONSE:	Frequency response is flat within ±1 db up to 700 mc and drops off less than 1 db at 20 cps. Probe resonant frequency is about 1,250 mc and an indication can be obtained up to 3,000 mc.
INPUT IMPEDANCE:	Input capacity is 1.5 $\mu\mu$f; input resistance is 10 megohms at low frequencies. At high frequencies resistance drops off due to dielectric losses. DC input resistance is approximately 122 megohms for all ranges.
PROBE:	The probe is approximately 1" diameter and 4-1/2" long. It is equipped with a ground clip, and the connector may be soldered to the point under test. Adapting connectors are available to measure voltages in coaxial transmission lines.
POWER SUPPLY:	115/230 volts ±10%, 50/1,000 cps, 40 watts.
SIZE:	Cabinet Mount: 11-1/2" high, 7-3/8" wide, 8-3/4" deep. Compartment at rear of instrument stores probe and test leads when not in use.
WEIGHT:	Cabinet Mount: 12 lbs.; shipping weight approximately 17 lbs. Rack Mount: 12 lbs.; shipping weight approximately 26 lbs.
RACK MOUNTING:	Available on standard RETMA 7" x 19" panel.
ACCESSORIES AVAILABLE:	hp 452A Capacitive Voltage Divider, 25 KV max., requires hp 452A-95A Adapter. hp 453A Capacitive Voltage Divider, 2 KV max. hp 455A Probe Coaxial "T" Connector, for Type "N" systems. hp 458A Probe Coaxial "N" Connector, terminates Type "N" systems. hp 459A DC Resistive Voltage Multiplier, 30 KV max.

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CAUTION

The a-c probe shell, the common ground clip lead, the instrument chassis and cabinet, and the green grounding lead in the three-conductor power cable are electrically connected together at all times. When the NEMA connector is used in the proper manner, a ground path is established between the 410B and equipment which is also grounded. Do not connect the ground clip lead or the a-c probe body to any point which is not at ground potential because a short circuit will be created. If such a measurement is necessary, disconnect the NEMA ground in the power cable by using an adapter with the grounding pig-tail removed, and the cabinet insulated from ground. The 410B cabinet will be at the same potential as the negative clip lead. Caution must be used if the clip lead is connected to a point which is more than a few volts off ground. Because of the potential hazard to personnel, this method is not recommended.

One side of almost all power distribution systems is grounded. Extreme caution must be used if direct measurement of power system voltages is attempted. If the ground clip lead is accidentally connected to the ungrounded side of the line, severe damage to the 410B is possible because of the short circuit created. Power line voltages can be safely measured by using the probe Tip only. Contacting the grounded power conductor will give a reading of 0 volts while contacting the ungrounded lead will give full line voltage reading.

The 410B is designed for the measurement of audio and r-f voltages and is excellent for this purpose. In normal practice these voltages are almost always measured with respect to chassis ground and no concern need be given to grounds. D-C voltages can almost always be determined by measurements with respect to ground, either directly or by subtraction.

SECTION I
GENERAL

1-1 GENERAL DESCRIPTION

The ℗ Model 410B is a laboratory quality volt-ohmmeter that has been especially designed for making accurate voltage measurements in the frequency range from 20 cps to over 700 mc per second, with useful indications at frequencies as high as 1500 megacycles. The instrument has full scale a-c ranges of 1, 3, 10, 30, 100 and 300 volts, with an input resistance of 10 megohms at low frequencies, shunted by 1.5 $\mu\mu$f. Dc ranges are provided with full scale values of 1, 3, 10, 30, 100, 300 and 1,000 volts. The dc input resistance is approximately 122 megohms on all ranges. The ohmmeter ranges have mid-scale values of 10, 100, 1,000, 10,000, 100,000, 1,000,000, and 10,000,000 ohms. Accurate resistance readings from 1 ohm to 500 megohms are easily made.

The meter scale calibration is very straight forward. All dc voltage ranges and ac ranges 10 volts and above are read on two black scales calibrated 0-1 and 0-3. Due to non linearity of the diode at very low voltages, the 1 and 3 volt ac ranges are read on special, separate, red scales.

All resistance readings are made on one OHMS scale. Figure 1-1 is a drawing of the 410B meter scales.

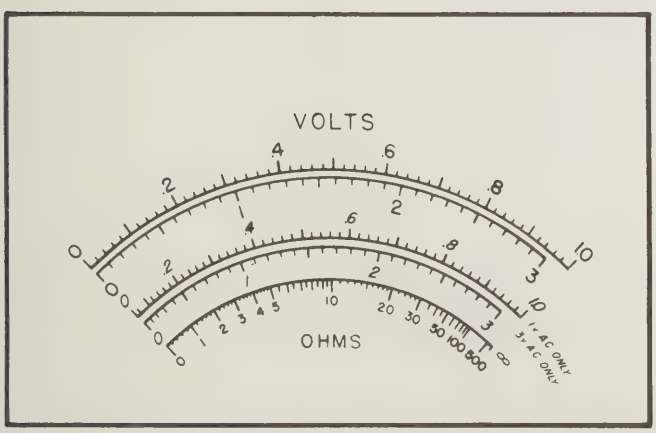


Figure 1-1. Meter Scale Calibration ℗ 410B

Power for the ohmmeter circuits is supplied by the instrument power supply which eliminates the necessity of using any battery with its attendent maintenance.

The high accuracy obtained with all voltage measurements makes the ℗ Model 410B useful for a wide variety of laboratory and field applications, especially in high frequency work. Construction of the a-c probe is such as to enable the operator to minimize lead length and input capacity, factors which usually restrict the high frequency range in instruments of this type. The wide range of a-c and d-c voltage and resistance measurements combined with convenience of operation make the 410B very useful for all types of circuit testing and trouble shooting as well as development work.

1-2 POWER LINE VOLTAGE

When the instrument leaves the factory, the dual 115 volt primary windings of the power transformer are connected in parallel for operation from a nominal 115 volt source. If operation from a nominal 230 volt supply is desired, the windings may be easily reconnected in series. Refer to the schematic drawing for details. Install the correct power line fuse as listed in the Table of Replaceable Parts.

1-3 THREE CONDUCTOR POWER CABLE

The three conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset round pin, **WHICH GROUNDS THE INSTRUMENT CHASSIS** when used with the appropriate receptacle. To use the NEMA connector

in a standard two-contact receptacle, a three-prong to two-prong adapter should be used. The ground connection emerges from the adapter as a short lead which should be connected to a suitable ground for the protection of operating personnel.

1-4 ACCESSORIES

The 410B is not furnished with any accessories, however a number of special accessories are made by ℗ which extend the a-c and d-c voltage range of the instrument and facilitate a-c measurements in coaxial systems. A description of these accessories and their specifications is contained below; the accessories are shown in Figure 1-2.

a. ℗ Model 453A Capacitive Voltage Divider - The Model 453A Capacitive Divider shown in Figure 1-2a extends the a-c voltage range of the 410B Multimeter to 2000 volts rms. The divider is for use at frequencies above 10 kilocycles. Voltage division is 100:1, ±1%, and the input capacity is approximately 2 micromicrofarads.

b. ℗ Model 452A Capacitive Voltage Divider - The Model 452A Capacitive Divider shown in Figure 1-2b extends the a-c voltage range of the 410B Multimeter to as much as 25 kilovolts. This divider permits measurement of extremely high a-c voltages such as are encounterd in dielectric heating equipment and similar applications. The frequency range of the divider is from 25 cps to 20 mc, although as frequency increases, the divider is de-rated to limit the r-f current flowing through its capacitors. A fixed gap is provided so that breakdown will occur if the applied voltage exceeds about 28 kv at low frequencies. Voltage division is 1000:1, ±3%, and the input capacity is 15 micromicrofarads. An adapter, ℗ 452A-95A, is also required to connect the 410B AC probe to the shielded banana plug fitting of the 452A. (The 452A fitting is designed for use with a ℗ 400D type meter.)

c. ℗ Model 458A Probe Coaxial "N" Connector - The Model 458A coaxial connector shown in Figure 1-2c allows the a-c probe of the 410B Multimeter to be connected to a 50-ohm coaxial line. The connector uses a female type N connector and a receptacle for receiving the a-c probe of the 410B voltmeter. No terminating resistor is included.

d. ℗ Model 455A Coaxial "T" Connector - For measurements at the higher frequencies the special T-joint shown in Figure 1-2d has been designed for connecting the 410B Multimeter across a 50-ohm transmission line using type N connectors. The T-joint has been designed so that the connection of the multimeter into a transmission line circuit will not cause a standing wave ratio greater than 1.1 at 500 megacycles and 1.2 at 1000 megacycles. With the aid of this device, measurement of power traveling through a transmission line may be made with reasonable accuracy to 1000 mc. The usual precautions must be taken to provide accurate impedance matching and the elimination of standing waves along the line through which power is flowing. By using a dummy load at the receiving end of this T-joint, power output of various devices can be measured. In many applications power going into a real load, such as an antenna, can be conveniently measured up to frequencies as high as 1000 megacycles with good accuracy.

e. ℗ Model 459A DC Resistive Voltage Multiplier The Model 459A dc voltage divider shown in Figure 1-2e extends the dc voltage range of the ℗ Model 410B to a maximum of 30 kilovolts. Division ratio is 100:1, ±5%, and the input impedance is 12,000 megohms. This probe offers maximum safety and convenience for measuring high voltages such as in television equipment, etc. The maximum circuit loading is 2.5 microamperes.

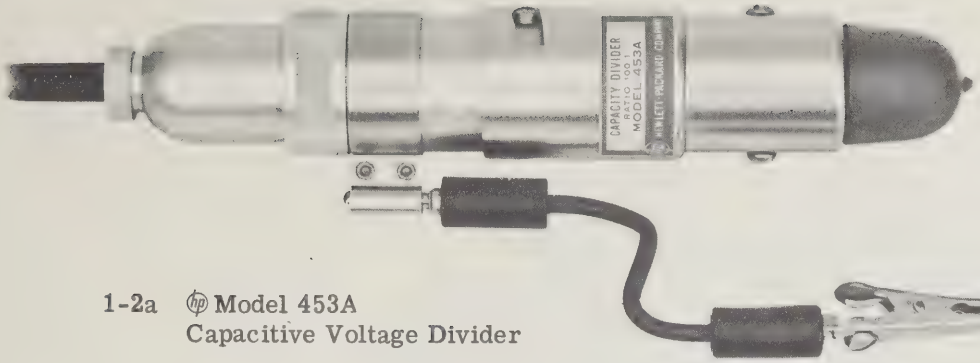
1-5 INITIAL ASSEMBLY OF THE PROBE ASSEMBLY

The 410B is shipped from the factory with the probe assembly packed in a compartment accessible by removal of the rear cover. The banana-plug connector should be plugged into the bottom of the instrument and secured with the two machine screws.

1-6 METER MOVEMENT MECHANICAL ZERO

Whenever the meter pointer does not indicate exactly on zero, the pointer should be reset to zero. For most accurate positioning of the pointer, turn the instrument on for about 15 minutes to allow it to reach operating temperature. Turn off the power and wait at least 30 seconds for the capacitors in the instrument to discharge.

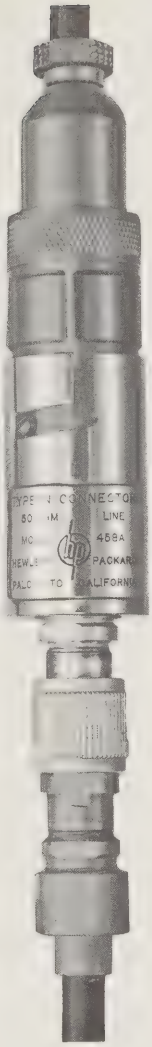
The adjust screw is in the meter frame at a midpoint immediately below the meter face. The adjustment is made properly only when the pointer is traveling in the opposite direction to the turn of the adjust screw. Although the adjust screw may be turned in either direction, a practical procedure is to turn the screw in a clockwise direction until the pointer starts to swing back toward zero. Then, still turning the screw clockwise, bring the pointer (now traveling counterclockwise), back to zero.



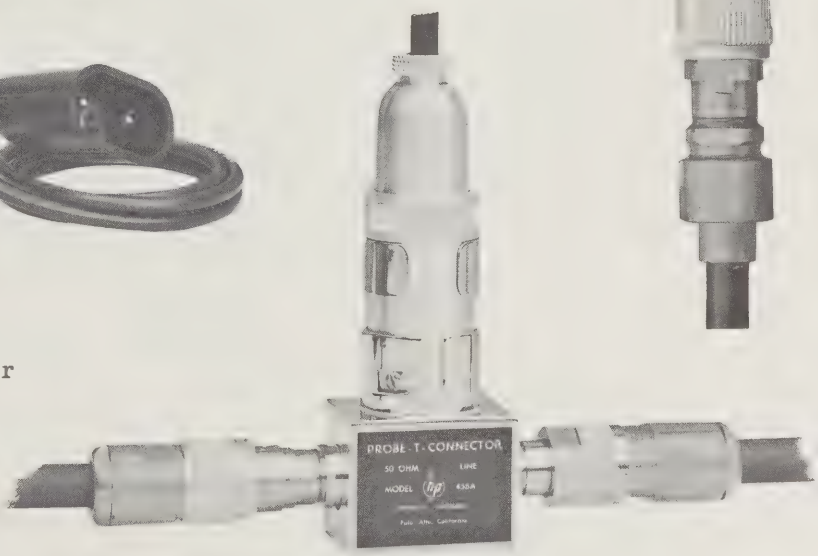
1-2a Ⓗ Model 453A
Capacitive Voltage Divider



1-2b Ⓗ Model 452A
Capacitive Voltage Divider
and 452A-95A Adaptor



1-2c Ⓗ Model 458A
Probe Coaxial "N"
Connector



1-2d Ⓗ Model 455A Coaxial "T" Connector



1-2e Ⓗ Model 459A DC Resistive Voltage Multiplier

Figure 1-2. Accessories for Model 410B

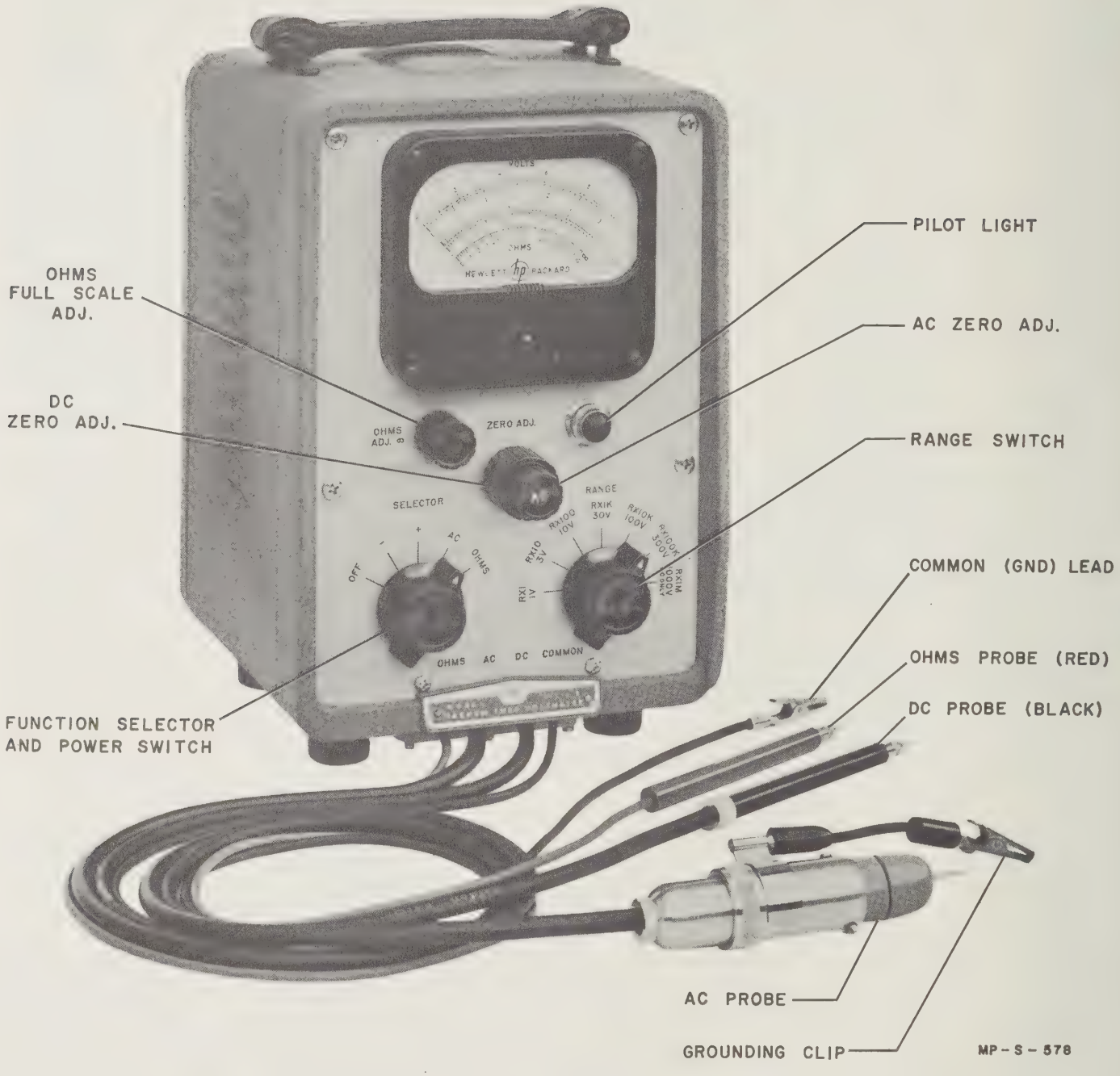


Figure 2-1. Model 410B Controls and Terminals Labeled

SECTION II
OPERATING INSTRUCTIONS

2-1 OPERATING CONTROLS AND TERMINALS

A description of each of the front panel controls, the test probes, and the meter follows:

SELECTOR - This five-position switch turns the instrument on; provides for measurements of negative or positive d-c voltage, a-c voltage, or resistance; and connects the appropriate probe for the desired measurement.

RANGE - This switch selects the full-scale voltage or resistance range to be used.

ZERO ADJ. - The larger, fluted knob is a basic zero adjustment that sets the meter pointer to zero when the SELECTOR switch is set at - and +. The smaller knob marked AC is used to set the meter pointer to zero following the basic zero adjustment and with the SELECTOR switch set to AC.

OHMS ADJ. ∞ - This knob adjusts the meter pointer to full scale (∞) when the SELECTOR switch is set to OHMS.

OHMS, AC, DC, COMMON - The designation at the bottom of the control panel identify the various test leads, which are connected underneath the instrument. The connector can be removed by unscrewing the two captive round head screws in either end of the connector. Once installed, the three probes need not be removed, although only the one probe in use is connected through the SELECTOR switch to the internal circuits. Each probe has the specialized function described below.

OHMS - The red rubber-covered cable with the red plastic prod is used in measuring resistance. The prod is equipped with a small chuck to hold a steel phonograph needle. The instrument is shipped from the factory with the sharp point of the needle inside the chuck and can be reversed if it is necessary to employ a sharp point for good connection. The probe is the negative side of the internal voltage source used for resistance measurements.

AC - A cable that terminates in the shielded probe is used for ac voltage measurements. The probe tip contacts the point in a circuit where a voltage is to be measured and the clip lead on the probe connects to the ground side of the circuit.

DC - The black, shielded cable with the black plastic prod is used to measure d-c voltages. The prod is equipped with a small chuck to hold a steel phonograph needle. The instrument is shipped from the factory with the sharp point of the needle inside the chuck and can be reversed if it is necessary to employ a sharp point for good connection.

COMMON - The black rubber-covered wire terminated in an alligator clip is the negative connection for all measurements except those made with the clip lead on the end of the AC probe. The common lead is connected directly to the chassis of the instrument and to the third grounding conductor in the power cable. When making resistance measurements this lead is positive with respect to the red prod.

FUSE - The fuseholder, located behind the cover in the rear compartment of the instrument, contains a 0.6 amp slow-blow, 115 volt line cartridge fuse replaceable by unscrewing the fuseholder cap and inserting a new fuse. A 0.25 amp slow-blow fuse should be used if the instrument is operated on 230 volts.

2-2 OPERATING ADJUSTMENTS

The hp Model 410B has three front panel operating adjustments: ZERO ADJ., AC ZERO ADJ., and OHMS ADJ. ∞. ZERO ADJ. sets the meter pointer to zero when the selector switch is in the - and in the + positions and must be adjusted before the AC and the OHMS adjustments are made. AC ZERO ADJ. adjusts the meter pointer to zero when the selector switch is in the AC position to compensate for any small residual meter reading that appears as the a-c probe is switched into operation. The

AC ZERO should be adjusted when the range switch is on the 1 volt range. OHMS ADJ. ∞ sets the meter pointer to full-scale when the selector switch is turned to the OHMS position.

2-3 STEP-BY-STEP OPERATING PROCEDURES

A. Basic Zero Adjustment

1) Connect the power cable to the power line. Set the SELECTOR switch to the (-) position and allow instrument to heat for five minutes for stable operation.

2) Connect the DC and COMMON test leads together. Adjust the ZERO ADJ. (outer concentric knob) control so that the meter indicates zero with the RANGE switch set to the 1 volt range.

3) Set the SELECTOR switch to + and note the meter reading. If the needle point has shifted, set ZERO ADJ. so that the needle returns to the same position for both - and + positions of the SELECTOR switch.

4) Proper zero set is indicated when the meter zero does not shift when the SELECTOR switch is changed from (+) to (-) and back.

B. AC Zero Adjustment

1) Make the Basic Zero Adjustment described above.

2) Set the SELECTOR switch to AC and set the RANGE switch to the 1 volt position.

3) Connect the AC probe clip lead to the probe tip.

4) Adjust the AC knob to bring the meter pointer to 0.

C. OHMS Full-Scale and Zero Adjustment

1) Make the Basic Zero Adjustment described above.

2) Set the SELECTOR switch to OHMS.

3) Adjust the OHMS ADJ. ∞ control so that the meter pointer indicates ∞ on the ohms scale. The OHMS and COMMON test leads must not be connected together when making this adjustment.

4) To use the ohmmeter without making the basic zero or AC adjustment, connect the OHMS and COMMON test leads together, set the RANGE switch to RX1K or higher range, and adjust the ZERO ADJ. (outside concentric knob) until the meter pointer indicates zero on the ohms scale.

5) With the OHMS test lead not shorted, set the OHMS ADJ. ∞ knob to bring the pointer to ∞.

The multimeter is now ready for operation. Before attempting to make an actual measurement, study the operating procedures described in the paragraphs below.

CAUTION

The voltmeter COMMON, the AC PROBE ground clip lead, the instrument chassis and cabinet are all electrically tied together at all times. In addition, the third (green) lead in the power cable is tied to the chassis. If the three prong NEMA connector is used in a proper mating receptacle, the 410B will be connected to the power system ground. When making voltage measurements, ac or dc, positive or negative, always connect the voltmeter COMMON or the AC PROBE ground clip lead to the chassis, or ground, of the equipment under test. Connecting the ground clip to any other point will automatically ground that point to the power system ground. If a ground path in the equipment under measurement also exists to the power ground, a short circuit will result. If a three-prong to two-prong adapter is used with the pig-tail ground lead disconnected, the cabinet of the 410B will assume the same potential as the point to which the clip lead is connected. For safety's sake, it is best not to make measurements with the ground clip lead connected to points not at chassis potential. In almost every case the measurement can be made successfully by reading the voltages with respect to ground and then subtracting one reading from the other.

2-4 PROCEDURE FOR MEASURING DC VOLTAGES

a. Make the basic zero adjustment described earlier in paragraph 2-3.

b. Set the SELECTOR switch to either the (+) or (-) position, depending upon the polarity of the voltage to be measured.

c. Set the RANGE switch to the range that includes the voltage to be measured.

d. Connect the COMMON test lead to the ground side of the circuit to be measured and touch the DC VOLTS prod to the point in the circuit being measured.

e. Read the measured voltage from the meter, multiplying the indicated value by the appropriate factor. Dc voltages are read from the two top meter scales, 0-1 and 0-3, printed in black.

2-5 PROCEDURES FOR MEASURING AC VOLTAGES

a. Make the AC ZERO adjustment described above.

b. Set the RANGE switch to the range that includes the voltage to be measured.

CAUTION: The ac probe blocking capacitor is rated at 500 volts, do NOT connect the ac probe to higher voltages. Before measuring voltages above 50 megacycles, consult Figure 2-2 a graph of maximum applied voltage vs. frequency. Certain other precautions apply to ac voltage measurements, they are discussed in paragraph 2-8.

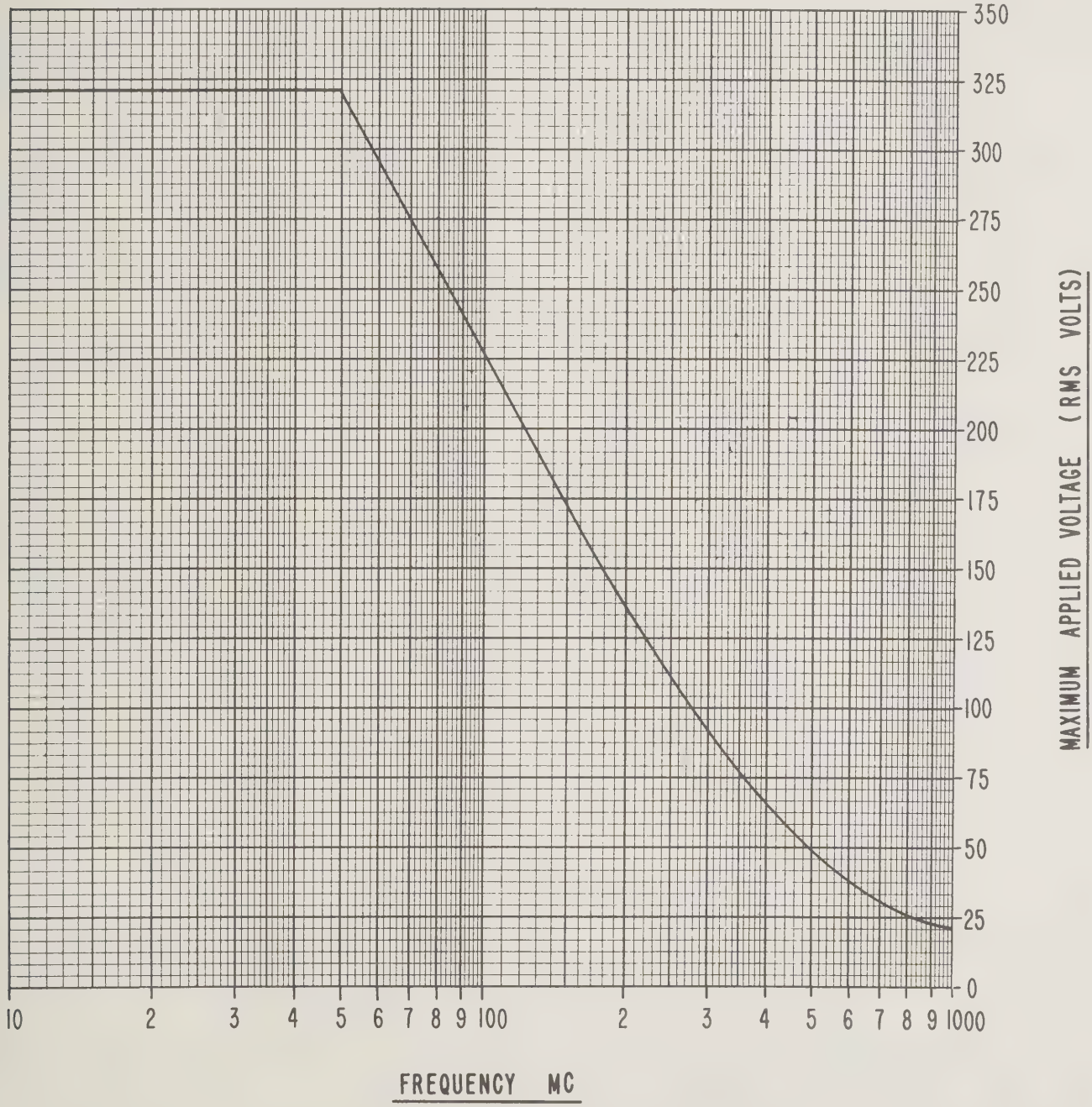


Figure 2-2. Maximum Voltage that can Safely be applied to AC Probe for Frequencies above 50 Megacycles

c. Connect the ground clip lead on the a-c probe to ground of the circuit being measured and touch the a-c probe tip to the other side of the circuit being measured. (For audio frequencies the ground lead from the voltmeter chassis may be used for negative connection instead of the ground lead on the a-c probe, if desired.)

d. The measured voltage is then read from the meter. The full-scale value of the meter is indicated by the setting of the RANGE switch.

NOTE

The 0 - 1V and 0 - 3V meter scales printed in red are for use only with the 1V and 3V a-c positions of the RANGE switch. The remainder of the alternating voltage ranges are read from the two top meter scales (0 - 1 and 0 - 3) printed in black.

2-6 PROCEDURE FOR MEASURING RESISTANCES

CAUTION

TURN OFF EQUIPMENT THAT IS TO BE TESTED BEFORE MAKING RESISTANCE MEASUREMENTS. Be certain that no residual voltages remain in the circuit being measured. When making a leakage resistance measurement on paper capacitors on the RX1Meg range, a reading of greater than ∞ is sometimes measured with the OHMS leads connected one way and a fairly low value of resistance will be measured with the OHMS leads reversed. This is caused by a surface charge in the dielectric of the capacitor which leaks out after the capacitor is first discharged and builds up another slight voltage across the terminals. Since the 410B operates at a very high impedance level, this small voltage will cause erroneous resistance readings. Generally, keeping the capacitor terminals shorted for a few minutes will reduce this charge to zero and a correct reading can be made. This phenomenon will not occur on any of the lower ranges.

a. Make the OHMS adjustment described in paragraph 2-3C.

b. Set the SELECTOR switch to the OHMS position.

c. Connect the COMMON and OHMS test leads to the resistance to be measured.

d. Set the RANGE switch to the position that gives the largest up-scale meter indication.

e. Read resistance value from bottom scale on meter. The resistance is equal to the scale indication times the multiplying factor shown by the position of RANGE selector.

f. Resistance readings up to a million megohms or higher are possible with an external battery. Refer to paragraph 2-10 for details.

2-7 ELECTRICAL CHARACTERISTICS OF THE DIODE AND PROBE

The ℗ Model 410B measures a-c voltages from 1 volt full-scale to 300 volts full-scale in the frequency range from 20 cycles to 60 megacycles and measures reduced voltages to 700 megacycles. The basic accuracy is ±3% for measurement of sine waves up to 60 megacycles per second, while the frequency response is ±1 db over the entire frequency range

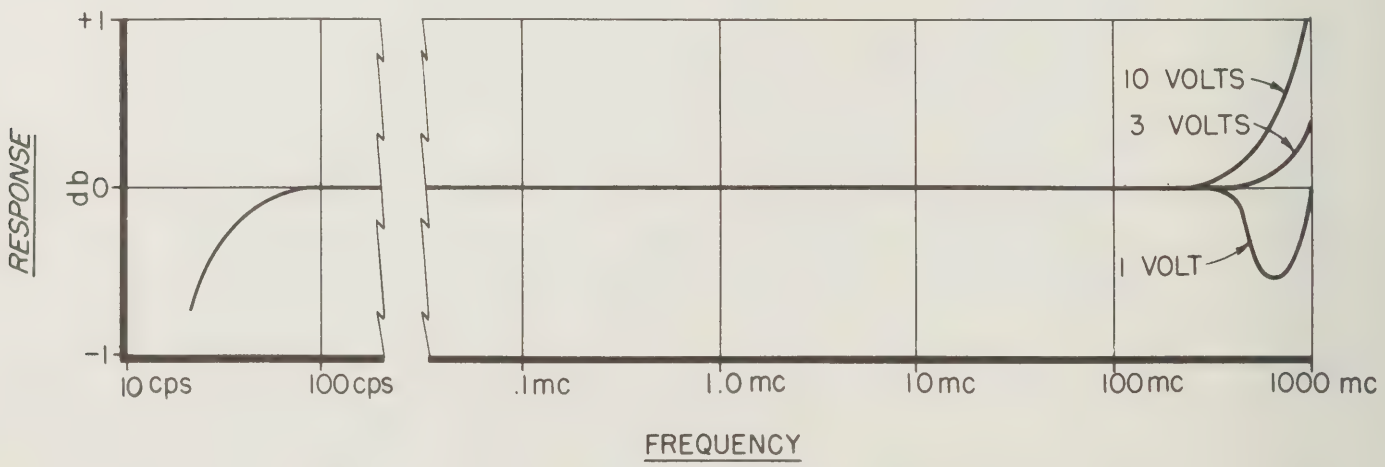


Figure 2-3. Ratio of Indicated to Actual Voltage as a Function of Frequency

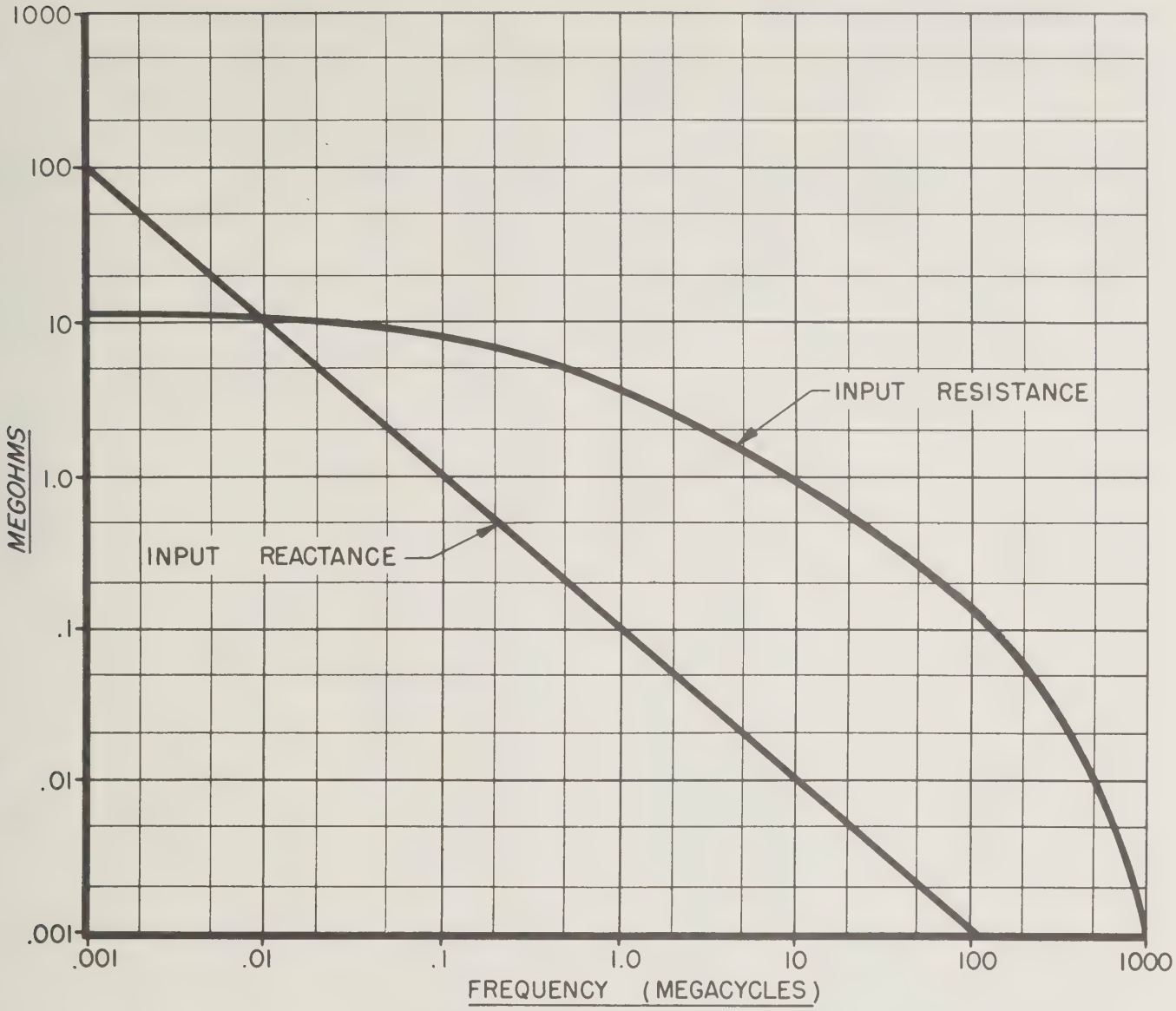


Figure 2-4. Input Resistance and Reactance of Model 410B Diode Probe

from 20 cycles to 700 megacycles per second. The 410B continues to be useful up to the probe resonant frequency of approximately 1250 megacycles, and indications can be obtained up to 3000 megacycles.

A performance curve for the probe, showing the ratio of indicated to actual voltage as a function of frequency, is plotted in Figure 2-3. At low and medium frequencies the response is flat. At high frequencies, however, the response is affected by two factors: transit time of the probe diode, which is dependent upon the magnitude of the applied voltage; and the resonant frequency of the probe, which is independent of the applied voltage. The effect of transit time is indicated by the dip in the 1-volt curve in the vicinity of 500 mc. The rise of the 3-volt and 10-volt curves is due to the effects of resonance in the probe, which overshadow the effects of transit time.

The input resistance and shunt capacitive reactance components in the circuit within the a-c probe are shown in the graph Figure 2-4. At low frequencies the input resistance exceeds 10 megohms, decreasing at higher frequencies because of dielectric and tube losses. The shunt capacity component of input impedance is approximately 1.5 micromicrofarads.

2-8 AC MEASUREMENT PRECAUTIONS

Special considerations must be kept in mind when making a-c voltage measurements. These considerations are discussed in the following paragraphs.

a. General Consideration of Complex Wavforms - Waveforms containing appreciable harmonics or spurious voltages will introduce errors in the meter indication since the meter has been calibrated to read rms values of true sine waves while the a-c probe is a peak-responding device. The magnitude of error that may be expected when harmonics are present on the measured waveform is indicated in the Table below.

Table 2-1. Possible Error when Measuring Voltage of Complex Waveforms

% Harmonic	True RMS Value	Model 410B Indication
0	100	100
10% 2nd	100.5	90 to 110
20% 2nd	102	80 to 120
50% 2nd	112	75 to 150
10% 3rd	100.5	90 to 110
20% 3rd	102	87 to 120
50% 3rd	112	108 to 150

b. Voltage Measurements at Frequencies below 50 Cycles/Second - Voltage measurements at frequencies as low as 10 cycles per second may be made to the unit's basic accuracy by removing the plastic nose on the a-c probe and using in its place a blocking capacitor of 0.25 microfarad in series with the exposed contact of the probe.

CAUTION: The gray insulating material of the probe of the 410B is polystyrene, a low melting-point material. It is not possible to solder to the contact which is exposed when the probe nose is removed without destroying the polystyrene.

c. Voltage Measurements at High Frequencies - At frequencies above 100 megacycles the distance between the point of voltage measurement and the anode contact of the a-c probe must be made as short as possible. If feasible, substitute a small button-type capacitor of approximately 50 micromicrofarads for the removable tip on the a-c probe. Solder one terminal of the button capacitor to the measurement point in the circuit and not to the probe contact. The probe contact (with tip removed) can then contact the other terminal of the capacitor for the measurement.

At frequencies above 100 megacycles considerable voltage may be built up across ground leads and along various parts of a grounding plane. Consequently, to avoid erroneous readings when measuring medium and high frequency circuits, use the ground clip lead on the shell of the probe. In some cases at the higher frequencies it may be necessary to shorten still further the grounding lead on the shell of the probe.

For all measurements at the higher frequencies hold the molded nose of the probe as far from the external ground plane or from objects at ground potential as can conveniently be done. Under typical conditions, this practice will keep the input capacitance several tenths of a micromicrofarad lower than will be obtained otherwise.

For a-c measurements above approximately 250 megacycles it is nearly mandatory that measurements be made on voltages which are confined to coaxial transmission line circuits. For applications of this type, the hp Model 410B is particularly suitable because the physical configuration of the diode and probe is that of a concentric line, and with a few precautions it can be connected to typical coaxial transmission line circuits with little difficulty.

To connect the hp Model 410B into an existing coaxial transmission line, cut the line away so the center conductor of the line is exposed through a hole large enough to clear the body of the voltmeter a-c probe. The nose of the probe should be removed for this type of measurement. Connect one terminal of a button-type capacitor of approximately 50 micromicrofarads to the center conductor of the coaxial line so that the other terminal of the capacitor will contact the anode connection of the probe. A close-fitting metal shield or bushing should be arranged to ground the outer cylinder of the probe to the outer conductor of the transmission line. This type of connection is likely to cause some increase in the standing wave ratio of the line at higher frequencies. The hp Model 455A Coaxial "T" Connector is designed to do this job with a vswr of less than 1.1 at 500 mc. See paragraph 1-5.

d. Effect of Parasitics on Voltage Readings - At frequencies above 500 megacycles, leads or portions of circuits often resonate at frequencies two, three or four times the fundamental of the voltage being measured. These harmonics may cause serious errors in the meter reading. Owing to the resonant rise in the probe circuit at frequencies above 1000 megacycles, the meter may be more sensitive to the harmonics than to the fundamental. To make dependable measurements at these frequencies, the circuits being measured must be free of all parasitics.

e. Effect of DC Present With AC Signal - When measuring small ac voltages, which are present at a point along with high dc potential, you may obtain a voltage reading which is in error. This is caused by a very small leakage current through the blocking capacitor in the tip of the ac probe, and

might occur when you attempt to measure a 1 volt ac signal at the plate of a vacuum tube.

If this leakage is a problem you should add an external blocking capacitor ahead of the probe tip. A Mylar or polystyrene dielectric capacitor of 0.005 μf or larger is recommended. The usual paper or ceramic capacitor will not have sufficiently high leakage resistance to eliminate the problem.

Factory specifications require that the probe tip blocking capacitor have not less than 100,000 megohms resistance, which is the highest value obtainable in a part that meets other requirements. This is very high, but still makes a 1000:1 voltage divider with the 122 megohms input resistance of the meter circuits when on the 1 volt ac range. A 100 volt dc potential will be divided down and will present (approximately) a 0.1 volt signal to the meter circuit. On higher ac ranges, the effect is reduced proportionately.

2-9 PULSE MEASUREMENTS

The 410B is a peak-responding rms calibrated type voltmeter and is designed to measure the positive peak value of the applied voltage. This property allows the hp Model 410B to be used to measure the positive voltage amplitude of a pulse, provided the reading obtained is multiplied by the following factor:

$$1.4\left(1+\frac{t_1}{t_2}+\frac{K}{PRF}\right)$$

where: t_1 is the duration of the positive portion of the voltage in microseconds,

t_2 is the duration of the negative portion of the voltage,

K is a factor which is a function of the source impedance of the pulse generator and of t_1, and is found in the graph of Figure 2-5.

PRF is the pulse repetition frequency in pulses per second.

In general this equation is applicable where the pulse repetition frequency is greater than 500 pulses per second and the positive pulse duration is at least 10 microseconds. For most cases when using high pulse repetition rates, the above factor will reduce to

$$1.4\left(1+\frac{t_1}{t_2}\right)$$

K can be found by use of the curve in Figure 2-5 when the impedance of the pulse generator R_O in kilohms and the duration of the positive portion of the pulse t_1 in microseconds are known.

As an example, suppose:

t_1 = 10 microseconds,

R_O = 2 kilohms and the pulse repetition frequency is 1000 pulses per second,

then $R_O/t_1 = 0.2$, K = 0.55, and the multiplying factor would then be

$$1.4\left(1+\frac{10}{990}+\frac{0.55}{1000}\right).$$

For the case of a 10 microsecond negative pulse and a pulse repetition frequency of 1000 pulses per second, t_1 would be 990 microseconds and t_2 would equal 10 microseconds. Thus, R_O/t_1 would be approximately 0, and therefore (from Figure 2-5) K would also be approximately 0. The multiplying factor would then be

$$1.4\ (1 + 990/10).$$

Hence, it may be seen that in the case of negative pulses of short duration much smaller readings will be obtained than for an equivalent positive pulse. As a result, large multiplying factors must be used and unless the pulse voltage is large, these measurements may be impractical.

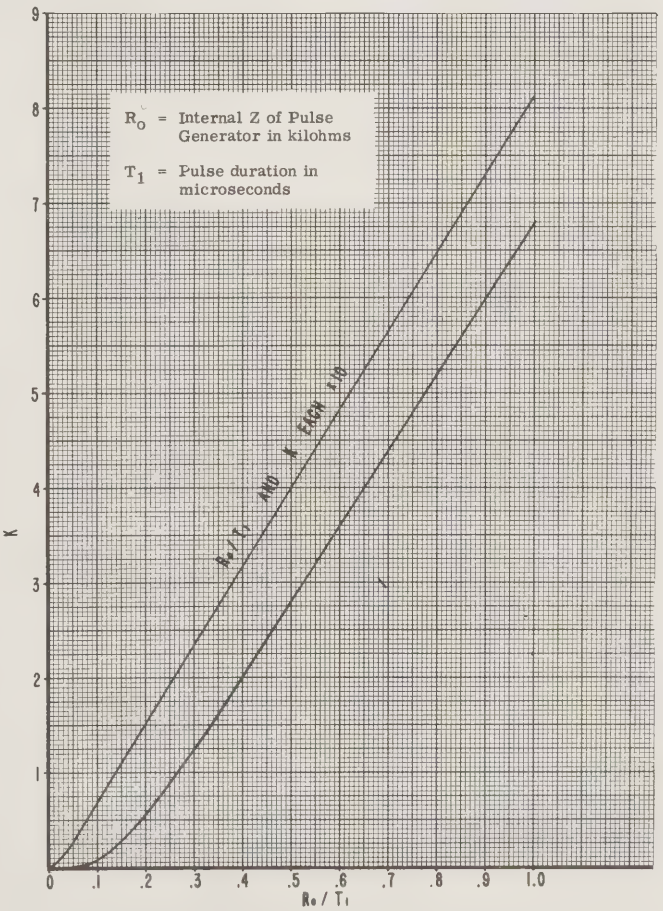


Figure 2-5. Graph used in Calculation of Pulse Voltages

2-10 RESISTANCE MEASUREMENT ABOVE 500 MEGOHMS

Because of its very high input resistance the Model 410B, supplemented by an external voltage, can be used to measure extremely high resistances. Any convenient d-c voltage up to 1000 volts may be used, the higher voltages permitting measurement of higher resistances. A 45-volt "B" battery extends the resistance measurement range to approximately 250,000 megohms. Resistances as high as several million megohms are easily and accurately made when the leakage between the test leads is held to a minimum by careful placement. The highest resistance that can be measured is limited by the total leakage between the DC test probe and the COMMON test probes on the voltmeter.

The measurement of extremely high resistance is accomplished by applying a known d-c voltage to the unknown resistance in series with the 410B as shown in Figure 2-6. The external voltage is first measured with the 410B and recorded. The positive side of the external voltage source is then connected through unknown resistance to the d-c measurement probe, the negative side of the voltage is connected to the COMMON lead from the 410B. The voltmeter range switch is then adjusted to obtain an upscale voltage reading. The meter indicates the voltage across the 122 megohm input resistance, which when multiplied by the ratio of the applied voltage to the measured voltage, minus one, gives the resistance of the unknown. The equation for determining an unknown resistance for any supply voltage and meter reading is given in the following equation. When the ratio of E applied to E measured is greater than 100:1, the minus one may be dropped with no practical loss in accuracy.

$$R_x = \left(\frac{E_{bb}}{E_m} - 1\right) R_m$$

E_{bb} = Externally applied battery or power supply voltage

E_m = Voltage read on d-c volts scale of voltmeter

R_m = Input resistance of voltmeter

(410A = 100 megohms)
(410B = 122 megohms)

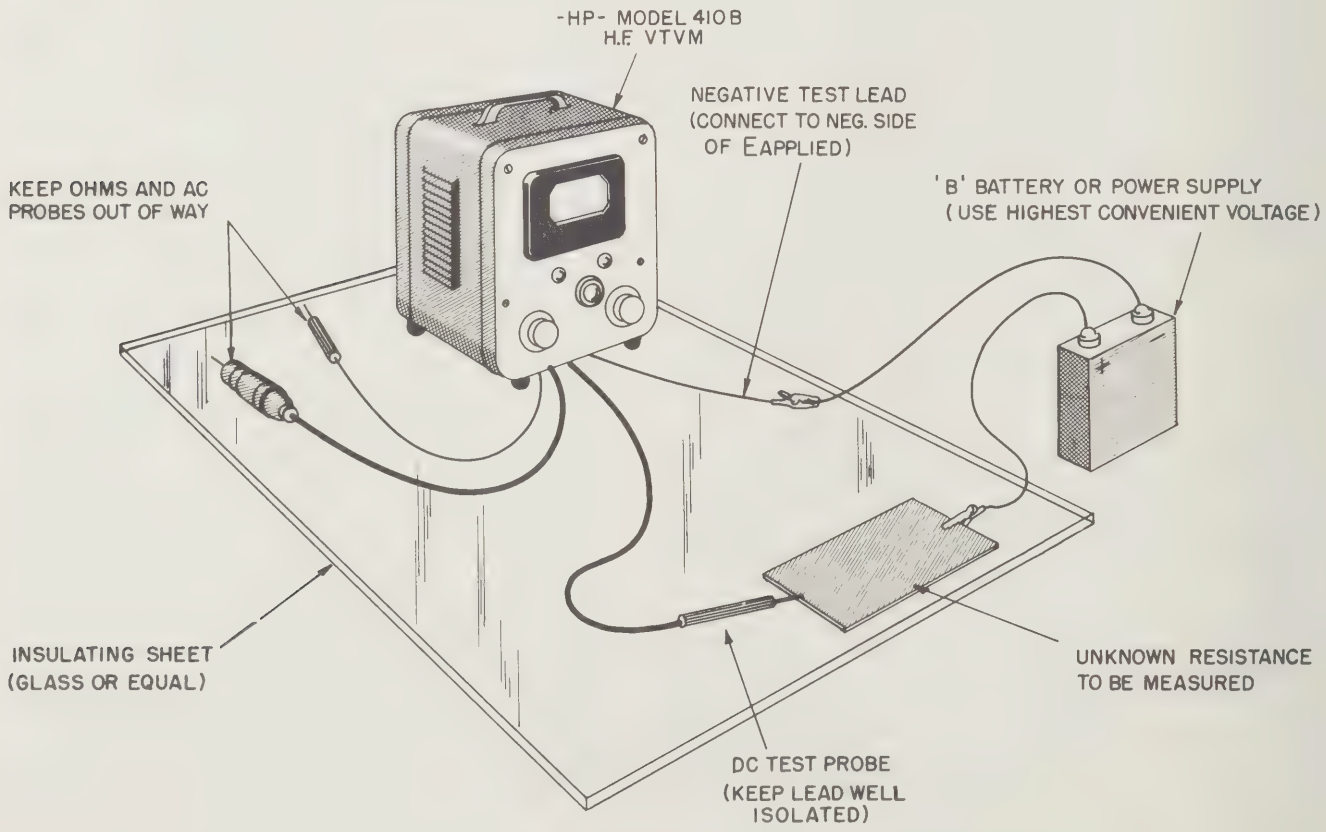


Figure 2-6. Setup for Measuring Extremely High Values of Resistance

SECTION III
THEORY OF OPERATION

3-1 GENERAL

The Model 410B is designed to measure the amplitude of a-c and d-c voltages and the values of resistances. To accomplish these measurements, the equipment's circuit is arranged as indicated by the block diagram of Figure 3-1. When measuring d-c voltages, the voltage to be measured is applied through a precision voltage divider to the input of a differential d-c amplifier. The output of the amplifier feeds a balanced bridge which has an indicating meter connected between the mid-points. The magnitude of deflection of the meter is thus proportional to the amplitude of the d-c voltage applied to the input of the differential amplifier.

When measuring a-c voltages, the voltage to be measured is converted to a d-c voltage in a special wide-band rectifier circuit. The output of the rectifier is then applied to the d-c voltage-measuring

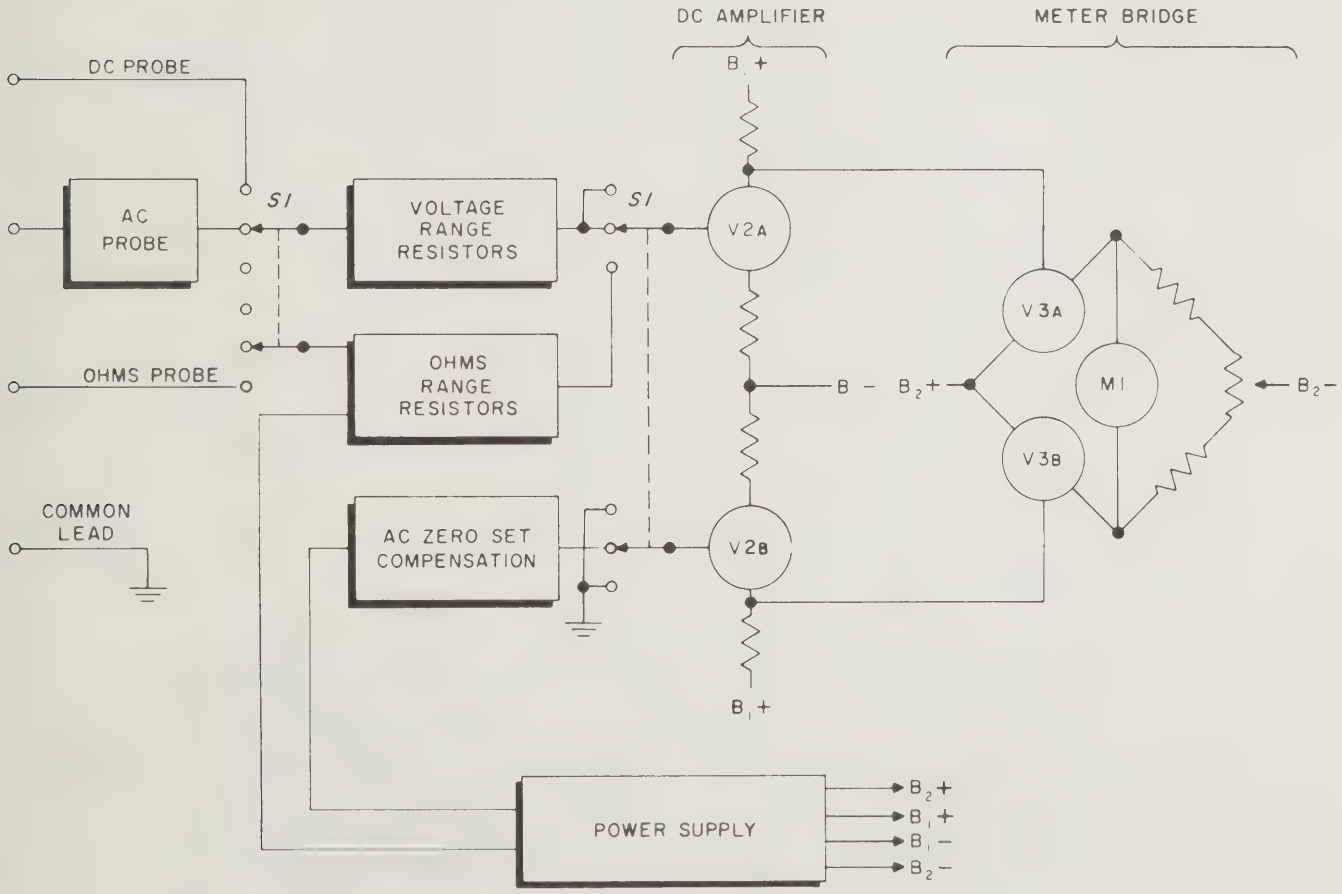


Figure 3-1. Block Diagram of Model 410B

circuit described above. A deflection of the indicating meter then occurs in proportion to the amplitude of the a-c voltage being measured.

For measuring resistance, a d-c voltage from the voltmeter power supply is applied through a large resistance to form a constant current source. This supplies a circuit consisting of the unknown resistance connected in parallel with a known resistance. The proportion of the internal voltage that appears across the unknown resistance is related to the ratio of the unknown to the known resistance. The voltage across the unknown resistance is then applied to the input of the differential amplifier as before, with the result that the magnitude of meter deflection is related to the value of the resistance being measured.

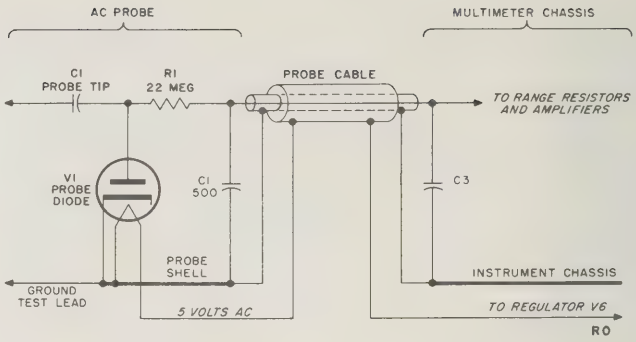


Figure 3-2. Schematic Diagram of AC Probe

3-2 R-F RECTIFIER

The circuit used for rectifying a-c signal voltages is shown in Figure 3-2. The circuit is a half-wave shunt-detector type circuit which operates to charge the small input coupling capacitor C1 to the peak value of the positive half of the a-c voltage being measured. To smooth the rectified a-c voltage for application to the differential amplifier, a large resistor (22 megohms) and capacitors C2 and C3 are connected across the output of the rectifier. The voltage across the capacitors rises to the peak value of the rectified wave and is applied through the precision voltage divider to the d-c amplifier.

Since the voltmeter is designed to be capable of measuring high frequencies, the rectifier circuit is built in the form of a probe so that it can be physically placed close to the point of measurement. The probe connects to the voltmeter proper through a flexible cable.

This arrangement permits short lead lengths for the actual a-c portion of the measuring circuit so that residual inductances will be minimized.

A cutaway view of the a-c probe showing the input blocking capacitor, rectifier diode, and RC filter is shown in Figure 3-3. The input capacitor is molded in a removable probe tip for applications where even the small lead length of the tip should be minimized. The diode is specially designed to have plane rather than circular geometry. This type of construction has been used in order to reduce the physical length of the diode and to achieve a diode having extremely low anode-cathode capacity. The construction is such that the probe has an input capacity of only about 1.5 mmf, about 1.3 of which is the anode-cathode capacity of the diode. To achieve short transit time for the diode, the anode-cathode spacing has been maintained at only .003 inch. Reliable r-f grounding of the diode cathode is obtained by use of a large area contact ring in the special socket for the diode. Figure 3-4 shows a line drawing of the probe diode.

The capacity in the RC filter is divided into two parts. A small 500 mmf capacitor, C2, is built into the probe near the base of the diode. At high frequencies this capacitor in combination with the 22-megohm filter resistor gives sufficient filtering so that the inductance of the flexible cable is of no consequence. For lower frequency filtering, Capacitor C3, is connected at the end of the cable inside the multimeter housing.

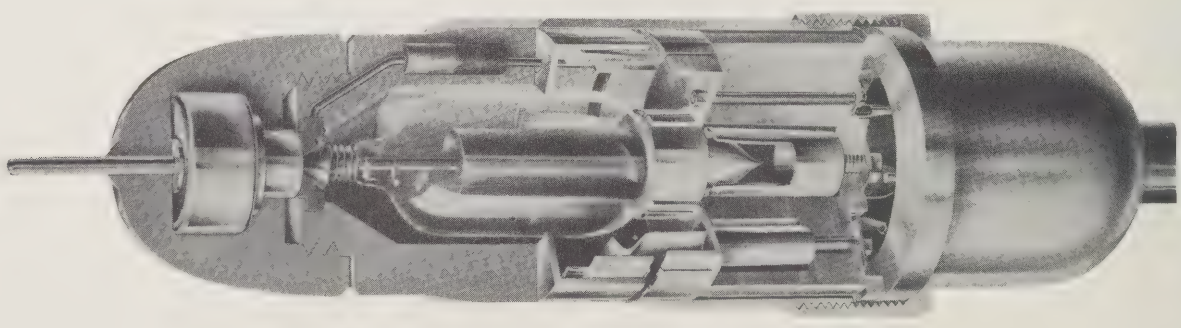


Figure 3-3. Cutaway View of High-Frequency Probe

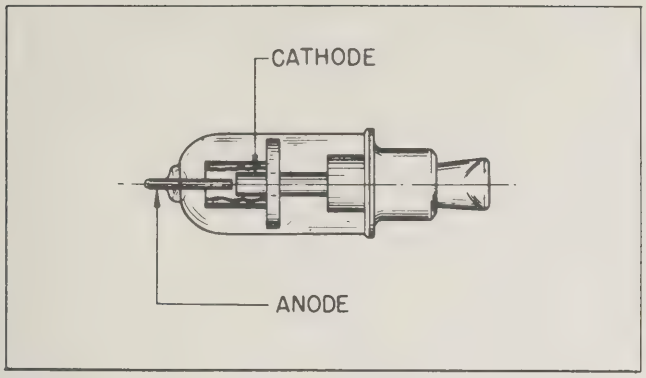


Figure 3-4. Actual Size Drawing of High-Frequency Diode

The probe is constructed from molded polystyrene to offer a low dielectric loss which, together with the low input capacity, makes the probe a high impedance device. The input impedance of the probe as a function of frequency is given in Figure 2-4.

The flexible cable connecting the probe to the voltmeter is a double-shielded single conductor cable. The outside shield carries a-c power for the diode heater; the inner lead carries the d-c voltage from the RC filter to the voltmeter. Ground return is made through the inner shield.

3-3 RANGE EXTENDING RESISTORS

To extend the voltage range over which both a-c and d-c measurements can be made, a precision voltage divider is connected to the input of the d-c amplifier. The taps on the divider are arranged so that the input to the amplifier does not exceed approximately .85 volt for a full-scale reading on d-c voltage measurements. On a-c measurements approximately 1.17 volts is applied to the amplifier for a full-scale reading. This increased voltage on a-c measurements is compensated by resistors in series with the indicating meter, as described later.

The precision voltage divider is made up of high-stability deposited carbon type resistors mounted on a seven-position rotary switch which serves as the range switch for the instrument.

3-4 DC AMPLIFIER

The taps on the precision voltage divider connect through the range switch to one input of the differential voltage amplifier. The amplifier consists of the two halves of a 12AU7 twin triode. The principle purpose of this amplifier is to serve as an impedance transformer between the 100-megohm impedance level in the range switch and the meter circuits. To achieve a high input impedance for the amplifier, it is operated without a grid resistor other than the 100-megohm voltage divider and at a low plate current in the order of a couple of microampers. Gas current effects in the high grid impedance are minimized by operating the amplifier tubes at a reduced heater voltage and a low plate voltage (approximately 20 volts). Very large cathode resistances are used to enhance the stability of the amplifier.

For a-c measurements the second or "balance" input to the differential amplifier is connected to a source of small d-c voltage in the power supply circuit. This arrangement is designed to compensate the voltmeter for "emission voltages" that occur in the probe diode. Because of the high thermal level of the probe diode cathode, electrons are emitted by the cathode even though no signal voltage is applied to the diode anode. Some of these electrons travel to the anode, giving it a net negative potential of approximately 1 volt, which will mask small signal voltages applied to the diode.

To compensate for this effect, the d-c voltage applied to the second input of the d-c amplifier is adjusted to be equal to the emission voltage of the diode. A voltage divider in the balance channel divides the compensating voltage in the same proportion as the input range switch divides the emission voltage so that the amplifier will always be compensated when the a-c probe is connected. The AC zero set control on the front panel adjusts the compensating voltage to exactly balance the voltage produced by the diode thereby bringing the meter to zero.

For d-c measurements the second input to the differential amplifier is grounded and serves only to supply a d-c level to balance the bridge.

3-5 METER CIRCUIT

The double-ended output of the differential amplifier is applied to a bridge circuit across which is connected the indicating meter, as illustrated by the diagram in Figure 3-5. Two arms of the bridge are triode tubes whose grids are connected to the two sides of the differential amplifier. With no voltage being measured, the two triodes have equal grid potentials and the bridge is in a balanced state. The front panel ZERO SET control R19a, a potentiometer located between the two legs of the bridge and the d-c supply voltage, establishes the exact electrical balance of the bridge for all types of operation. Potentiometer R32 is connected in series with the meter to adjust the sensitivity of the meter circuit to the precise required value.

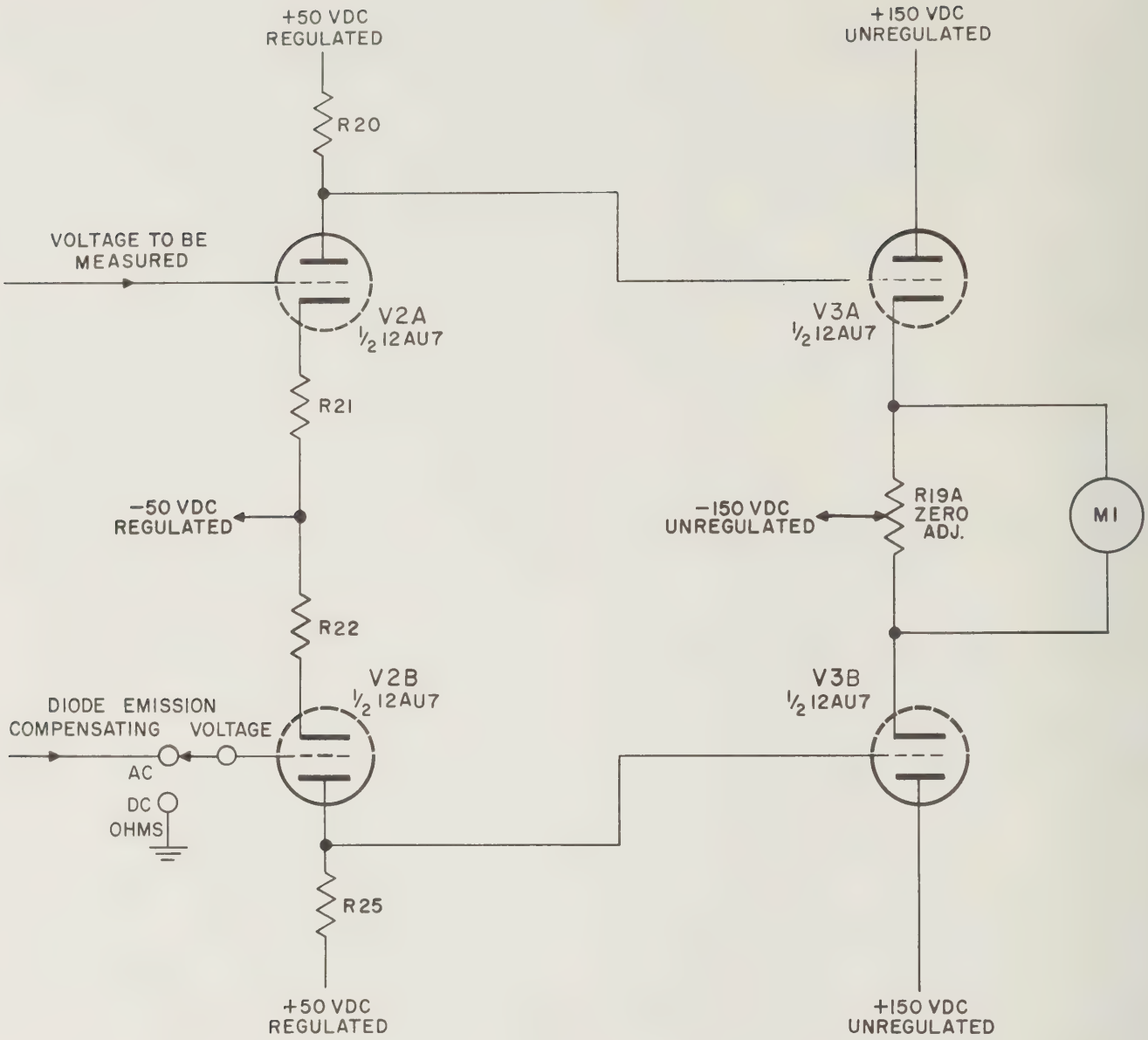


Figure 3-5. Basic DC Amplifier Circuit

To permit measurement of either positive or negative d-c voltages without reversal of the test leads the SELECTOR switch reverses the meter within the bridge so that an up-scale reading is obtained with either polarity.

For a-c measurements the range switch of the voltmeter connects in series with the meter additional current-reducing resistors (R35 through R40) to reduce the meter current by approximately 30% so that the same meter scale can be used for the a-c and d-c ranges. For the one and three volt a-c ranges, however, it is necessary to use special meter scales because the probe diode operation at low voltages is non-linear.

For resistance measurements the SELECTOR switch connects the meter in series with the front panel OHMS ADJ. ∞ control which adjusts the sensitivity of the meter to obtain a precise full-scale indication before making a measurement.

3-6 RESISTANCE MEASUREMENT

When the multimeter is to be used to measure resistance, the range switch connects an additional set of precision resistors to the input of the d-c amplifier as shown in the block diagram in Figure 3-1. A small, stable voltage of about 1.2 volts is taken from the regulated power supply and applied through a precision resistance to the input of the d-c amplifier thereby causing full-scale deflection of the meter. The resistance to be measured is then connected between the input of the d-c amplifier and ground. This resistance thus completes a voltage divider and reduces the voltage applied to the amplifier, bringing the meter reading down-scale. The range switch of the multimeter connects appropriate values of precision resistors into the ohmmeter circuit to extend the resistance-measuring range. (On the RX1 range the necessary voltage comes from a small selenium rectifier which is not regulated.)

3-7 POWER SUPPLY

The power supply circuit includes a full-wave rectifier with an RC filter at the output of the rectifier. An OB2 105-volt regulator tube provides regulated d-c voltage for operation of the differential d-c amplifier, ohmmeter circuits, and diode compensating circuits. D-c power for operating the bridge is obtained directly from the rectified output of the power supply. A regulated heater voltage of 5 volts a-c is also provided for the probe diode, regulation being obtained through the use of the constant current ballast tube V6. Potentiometer R50 shunting the diode heater is used to adjust the voltage across the heater to 5 volts. A small resistor is connected in series with the heater of V2 to operate this heater on approximately 4-1/2 volts. The heater winding also supplies a voltage which is rectified by a metallic rectifier for the RX1 resistance OHMS range only. This voltage is adjusted to approximately 1.2 volt by R49 to obtain full-scale deflection on the RX1 range consistent with that on the RX10 range, when the line voltage is at 115 volts.

The power transformer for the multimeter is equipped with two primary windings so that the instrument may be connected for operation on either 115 or 230 volt power. The windings are connected in parallel for use with 115 volts, and in series for 230 volts. For proper phasing of the windings the terminals on the transformer are numbered and wired as shown on the schematic diagram for the multimeter.

SECTION IV
MAINTENANCE

4-1 INTRODUCTORY

No routine maintenance procedures are required for the ㊍ Model 410B. When replacing any of the tubes in the equipment, however, it is desirable to check the accuracy of the multimeter. To do this it is necessary to have a precision d-c voltmeter and a precision a-c voltmeter, preferably of the dynamometer type. The accuracy of these instruments should be within 1-2%, because the basic accuracy of the 410B is within 3%. The procedure to follow in checking and adjusting the calibration of the instrument are described in paragraphs 4-4 and 4-5.

If a tube failure occurs after an extended period of use such as 1000 hours of operating time, it is desirable to replace all tubes at that time, to avoid need for more frequent recalibration than necessary.

A trouble-shooting chart listing possible operating troubles is included at the end of this section (paragraph 4-7).

4-2 TUBE REPLACEMENT

REPLACING V1 -
When replacing probe diode V1, some change in a-c voltage-measuring accuracy may occur on the lower three a-c measuring ranges of the instrument. In a typical case these changes will be less than 2%. With some diodes the changes can be greater than this, however, so it is desirable to recheck calibration accuracy.

The quality of the individual replacement diode will also effect the high frequency accuracy of the instrument. However, specialized equipment is necessary for checking the high frequency accuracy. If high frequency errors are suspected with a new diode installed, it is recommended that another replacement diode be tried.

The heater voltage should be checked when probe diode V1 is replaced. Accurate setting of this voltage is necessary to insure proper operation and maximum life of the probe diode. To check the heater voltage of probe diode V1:

1) Remove back cover from the instrument by pushing down the button at the top rear of cabinet and slide the back cover off.

2) Remove two retaining screws from instrument rear and slide instrument chassis forward out of cabinet.

3) Connect 410B to variable power transformer, set line voltage to 115 volts (or 230 volts) and turn 410B on.

4) Connect an ac voltmeter such as ㊍ Model 400D/H/L or Model 403A, between pin 7 of V6 (ballast tube) and chassis ground. If necessary, adjust R50 to obtain 5.0 volts rms.

REPLACEMENT OF V2 AND V3 -
When V2 or V3 are replaced, five checks should be made:

1. Amplifier balance with line voltage at 115 volts.
2. Microphonics: stability of the zero adjustment when the tubes are jarred.
3. Amplifier balance with line voltage change from 103 to 127 volts.
4. Gas in V2.
5. Voltage calibration.

NOTE

The following instructions describe a procedure which will provide optimum instrument performance over a wide range of line voltages. It is based on the procedure used at the factory. If such performance is not needed, the care in selection of tubes can be reduced considerably.

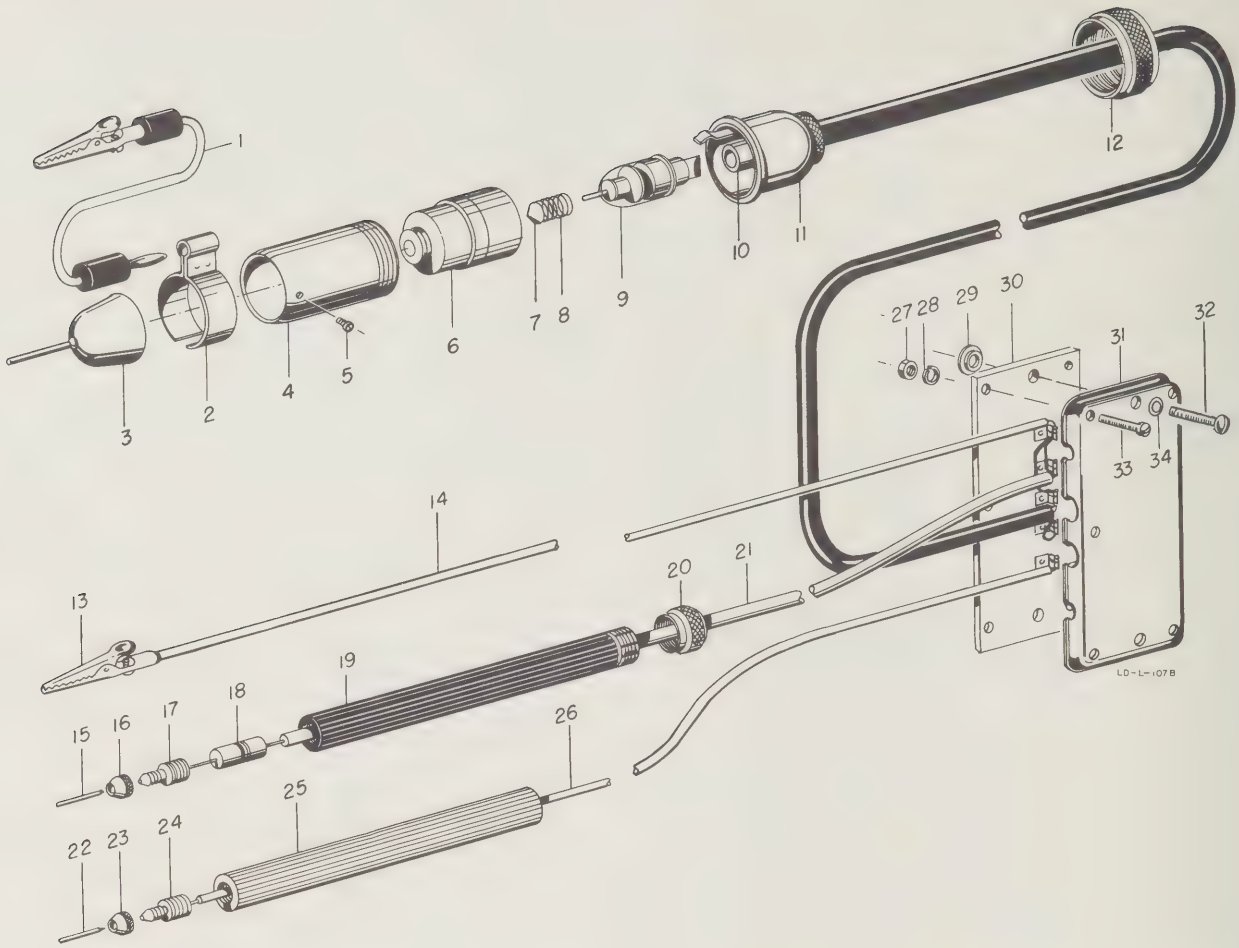


Figure 4-1. Test Probe Assembly, Including Exploded View of AC Probe

The following steps should be performed in the order given. If a tube fails to pass any test, it must be replaced and all tests repeated again in the proper order.

To obtain maximum range of adjustment of the ZERO SET control it is necessary that the four triode sections of the two 12AU7 tubes be similar in plate current characteristics. It is possible to have a combination of tubes which will have very little zero adjustment range on, say, (+) DC VOLTS and an excessive amount on (-) DC VOLTS. This is caused by non-uniformity between tubes. These characteristics also change considerably in the first 50 hours of tube operation.

A suggested method for determining if individual tubes are reasonably balanced is to first remove V2. With V3 only in its socket, check the ZERO ADJUST range on both (+) DC and (-) DC. Ideally, it should be the same in both positions of the FUNCTION switch. Select several tubes which are as nearly balanced as possible, by trying them in the V3 socket. Use the tube which has the best balance for V2 and the next best for V3. To insure the best margin of zero adjustment, the tubes should be selected to allow the ZERO ADJUST control to move the meter pointer at least 1/3 of the way up scale both with (+) and (-) DC VOLTS positions of the FUNCTION switch, when both tubes are in their sockets. Next, check for microphonics by first accurately setting the ZERO ADJUST to zero the meter and then tap V2 and V3. If the meter zero irratically changes position, one or both of the tubes have loose elements, which allow the static plate current to change value when jarred. Generally,

V2 is the most sensitive and should be suspected first. If the elements in V3 are very loose, it will cause the same indication. The defective tube or tubes should be replaced with ones which are of more sound construction. The balance test must be again repeated as described above.

To insure that the cathode emission is ample, the line voltage should be set to 115 volts. Allow the instrument to heat run for at least 5 minutes. Zero set the meter. Reduce the line voltage to 103 volts for a period of at least 1 minute. If the tubes have good cathode emission characteristics, the meter zero will not drift more than approximately 5%. If the zero drifts down scale to the left, the amount of drift can be measured from changing the position of the FUNCTION switch to the opposite polarity: (+) to (-) or vice versa, depending on the original position, so an up scale reading is obtained.

If the drift is not excessive, return the line voltage to 115 volts and reset the meter zero. After the tubes have stabilized at 115 volts, raise the line voltage to 127 volts and repeat the drift check. Again the drift should be less than 5%. If not, try another tube or tubes. V2 should be replaced first and then V3. All previous steps should be repeated first.

To check for a gassy V2, first accurately zero set the meter. Check the accuracy of the setting by switching the FUNCTION switch from (+) to (-) and back. If the setting is perfect, the meter pointer will not move. Feed in a d-c voltage of exactly 1.0 volt. (To facilitate this test the voltage should be fed through a dpdt switch so that the polarity can be quickly switched. If this is not done, it is very difficult to determine by eye if the two readings are the same within 1%).

If V2 is gassy, a certain error exists on the 1 volt range due to the gas current flowing through the 100 megohm resistive divider. Since the basic amplifier gain is set with the FUNCTION switch set to (+), this error is compensated for when the gain is set. When the polarity is reversed, however, the grid is biased negatively by the measured voltage and the value of the gas current changes somewhat. This results in a different reading.

A second method of checking for gas current is, to first accurately set the meter zero as described above. The RANGE SWITCH should be on the 1 VOLT DC range. Rotate the RANGE SWITCH to 300 VOLTS. If the input tube V2 is gassy, the zero will shift when the RANGE SWITCH is rotated. The grid impedance to ground is 100 megohms on the 1 VOLT range and approximately 300,000 ohms, on the 300 volt range (neglecting a fixed 5.6 megohm resistor). The effects of the gas current are thus reduced as the RANGE SWITCH is advanced to a higher range, which in turn causes the meter zero setting to change. NOTE: The effects of this test should not be confused with those of microphonic tubes. The Microphonic tube test must have been passed first.

Final voltage calibration should be made after tubes have been installed which pass all the above checks. Since the gain characteristics change somewhat during the first fifty hours of operation, it is desirable to heat run the instrument for at least this long before a final calibration is made. The calibration procedure to be followed after replacement of V2 or V3 is described in paragraph 4-4.

4-3 REPLACEMENT OF BALLAST TUBE V6

Failure of V6 is usually caused by overloading due to shorts. For this reason, before installing a new ballast tube, it is recommended that the resistance between pin 7 of V6 and ground be checked with V6 removed from socket. The resistance will initially read 2 to 3 ohms and slowly increase. If the reading does not increase to above 4 ohms, there may be a short. If the resistance increases to over 4 ohms, it is ordinarily safe to install the new ballast tube.

After installing the new ballast tube, measure the heater voltage of probe diode V1 (see para. 4-2).

4-4 BASIC VOLTAGE CALIBRATION

Before attempting to adjust either the a-c calibration accuracy or the ohmmeter calibration accuracy, it is necessary that the calibration of the d-c measuring circuits be accurate. Checking the d-c calibration accuracy is also recommended after replacing V2 or V3. The procedure is as follows:

a. Connect multimeter to a 115-volt power source and allow to heat for at least 15 minutes. It is desirable that the line voltage be accurately adjusted to 115 volts or to the predominating line voltage value if that value is somewhat less or more than 115 volts. The power transformer in the equipment is also designed to accommodate 230 volt lines; if the equipment is operated from 230 volt lines, the above information should be modified accordingly.

b. Remove the back cover from the instrument. To remove the cover push down the button at the top rear of the cabinet and slide back cover off.

c. Zero set the instrument with the RANGE switch set to the 1 volt range and the SELECTOR switch set to the + and - positions as described in paragraph 2-5.

d. Set SELECTOR switch to +. Range switch should remain at 1 volt.

e. Apply exactly 1 volt d-c to the d-c test leads. This 1 volt value can be obtained using a battery and potentiometer arrangement. The voltage applied to the voltmeter should be monitored and adjusted using the precision d-c meter described earlier. With exactly 1 volt applied to the multimeter the meter pointer should indicate an exact full-scale reading on the uppermost scale. If necessary, adjust R32 through the back of the instrument to make the meter read exactly full-scale. R32 is identified in Figure 4-2 and by appropriate markings on the back of the instrument.

f. The calibration of the remaining d-c ranges should now be checked insofar as the external precision meter and d-c source will permit. No adjustment circuits are provided, however, for the remaining d-c ranges. The accuracy of these ranges is determined by the values of the precision range switch resistors R3 through R9. A gross inaccuracy in any of the remaining d-c ranges indicates an incorrect range resistor or resistors.

g. Check a-c calibration accuracy as described below.

4-5 AC VOLTAGE CALIBRATION

The accuracy of the a-c voltage ranges of the multimeter should be checked after the probe diode V1 has been replaced. Before checking the a-c ranges, it is desirable to adjust the basic d-c voltage calibration as described above in paragraph 4-4. The procedure for checking and adjusting the a-c calibration is as follows:

a. Adjust line voltage as described in step a. of paragraph 4-4 above; remove back cover as described in step b. of the same paragraph.

b. Set SELECTOR switch to a-c and RANGE switch to 1 volt position. Allow equipment to heat for at least 15 minutes with these switch settings.

c. Set the FUNCTION switch to (+) DC and set the meter zero. Check by switching from (+) to (-) and back. There should be no shift. Set the FUNCTION switch to AC. Zero set a-c circuit with the AC ZERO control. (The RANGE switch still at the 1 volt position.)

d. Apply to the a-c probe a voltage of exactly 1 volt rms. This voltage should have an accurate, undistorted sine waveform. The frequency of this voltage should preferably be 100 cps or higher if permitted by the frequency characteristic of the dynamometer voltmeter. A good voltage source for this purpose is an accurate audio oscillator such as the ℗ Model 200AB, 205AG, etc. To determine that the voltage applied to the probe is accurate, it should be monitored by the precision dynamometer type voltmeter.

e. With exactly 1 volt rms applied to the probe, the voltmeter should indicate exactly full-scale on the 1 volt a-c (red) meter scale. If not, adjust R35 (available through back of instrument).

f. Set the RANGE selector to the 3-volt range. Increase voltage applied to probe to exactly 3 volts rms. Adjust potentiometer R39 to obtain accurate full-scale reading on the 3 volt a-c (red) meter scale.

g. Calibrate the remaining a-c ranges, reading the 1 and 3 volt d-c (black) scales of the meter. The following chart shows the adjusting potentiometers for each of the a-c ranges.

RANGE Switch Setting	Calibrating Voltage	Adjustment Resistor
1V	1V RMS	R35
3V	3V RMS	R39
10V	10V RMS	R40
30V	30V RMS	R36
100V	100V RMS	R37
300V	300V RMS	R38

4-6 OHMMETER ADJUSTMENTS

No internal adjustments are provided for the ohmmeter circuits other than for the full-scale setting of the RX1 range. The full-scale setting of the RX1 range may begin to differ from that of the other ranges as selenium rectifier CR1 ages. (Assuming the line voltage is the same value as when R49 was originally set.) To adjust the full-scale setting of the RX1 range to be equal to the full-scale setting of the other ranges, proceed as follows:

a. Connect multimeter to power line and allow to warm up. Normally the multimeter should be operated from 115 volts; however, if it is to be operated at line voltages substantially higher or lower than 115 volts the adjustment may be made at the expected line voltage.

b. Zero set the instrument as described in paragraph 2-3.

c. Set RANGE switch to RX10 range and adjust OHM ADJ. ∞ for exact full-scale meter reading.

d. Set RANGE switch to RX1 range.

e. If meter pointer does not read exactly full-scale (∞), remove back panel from multimeter case and adjust R49 as necessary.

The accuracy of the RX1 range is not affected if the full-scale (∞) is not the same for RX1 and RX10 and above, since the OHMS ADJ. ∞ control should be adjusted to bring the pointer to (∞) before measurements are made.

4-7 TROUBLE SHOOTING CHART

Table 4-1. Trouble Shooting Chart

SYMPTOM	CAUSE OF TROUBLE	REMEDY AND CHECKS
AC power cord plugged in, instrument turned on, pilot light does not light and no readings obtained.	Defective power cord, plug, or receptacle.	Check power source and connections.
	Fuse (F1) blown.	Check fuse (F1) and rectifier tube V5.
	Defective a-c Switch.	Check power switch continuity.
No readings obtainable, no zero adjustment, pilot lamp lights.	Defective tubes V2, V3 or V5.	Check V2, V3, and V5, if necessary, replace and recalibrate, see paragraph 4-2.
Zero set drift or zero set not possible.	Defective tubes V2 and V3.	Check tubes V2 and V3, replace and recalibrate, see paragraph 4-2.
No a-c readings, d-c readings normal.	Probe cap loose, defective V1 or V6.	Tighten probe cap. Check V1 for operation.
A-c zero set drifts or inaccurate a-c readings only on all ranges.	Defective V1.	Replace V1 and recalibrate as instructed in paragraph 4-3.
A-c zero set not possible.	Outside shield of a-c probe cable shorted to ground.	Check cable and repair short.
Inaccurate d-c and a-c readings.	Defective V2 or V3, defective range resistor (R3 through R9), misadjustment of R32.	Check V2 and V3 or R3 through R9, readjust R32 as instructed in paragraph 4-4.
Erroneous resistance readings following use of OHMS probe on high d-c voltage.	Burned resistors R10 through R13.	Check resistors R10 through R13 and if necessary, replace burned resistor.

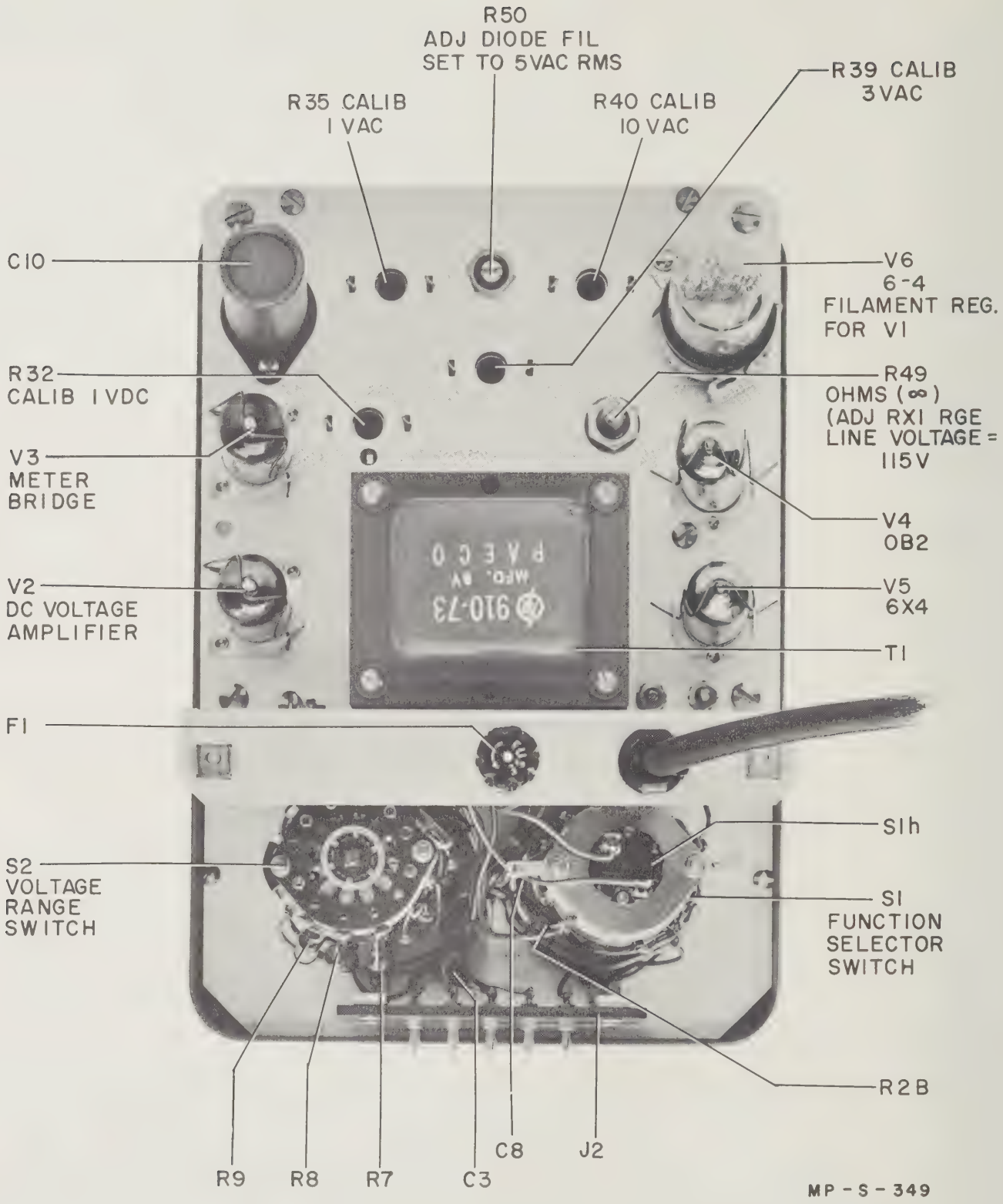


Figure 4-2. Rear View of Model 410B Chassis Removed from Instrument Case

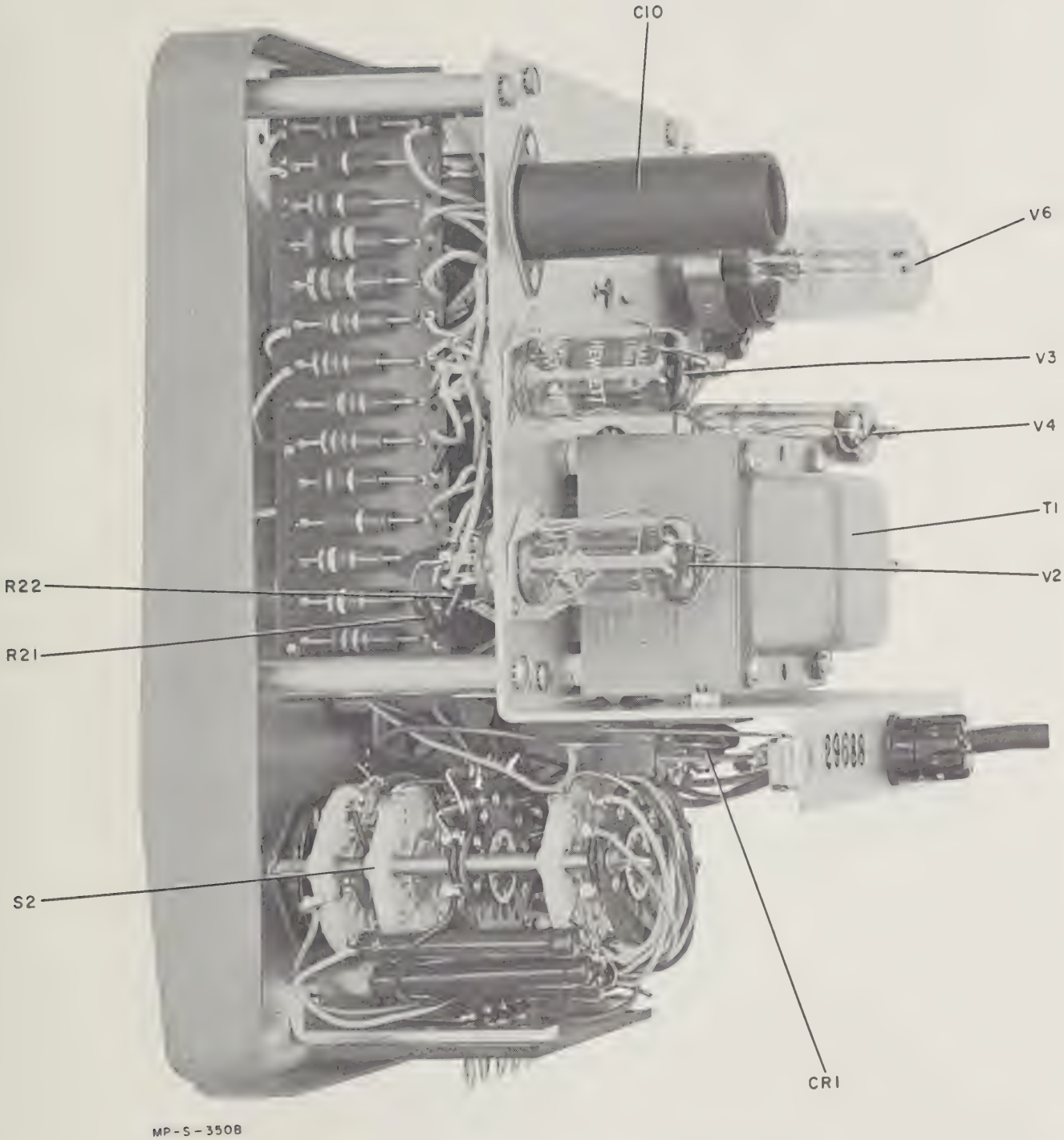


Figure 4-3. Right Side View of Model 410B

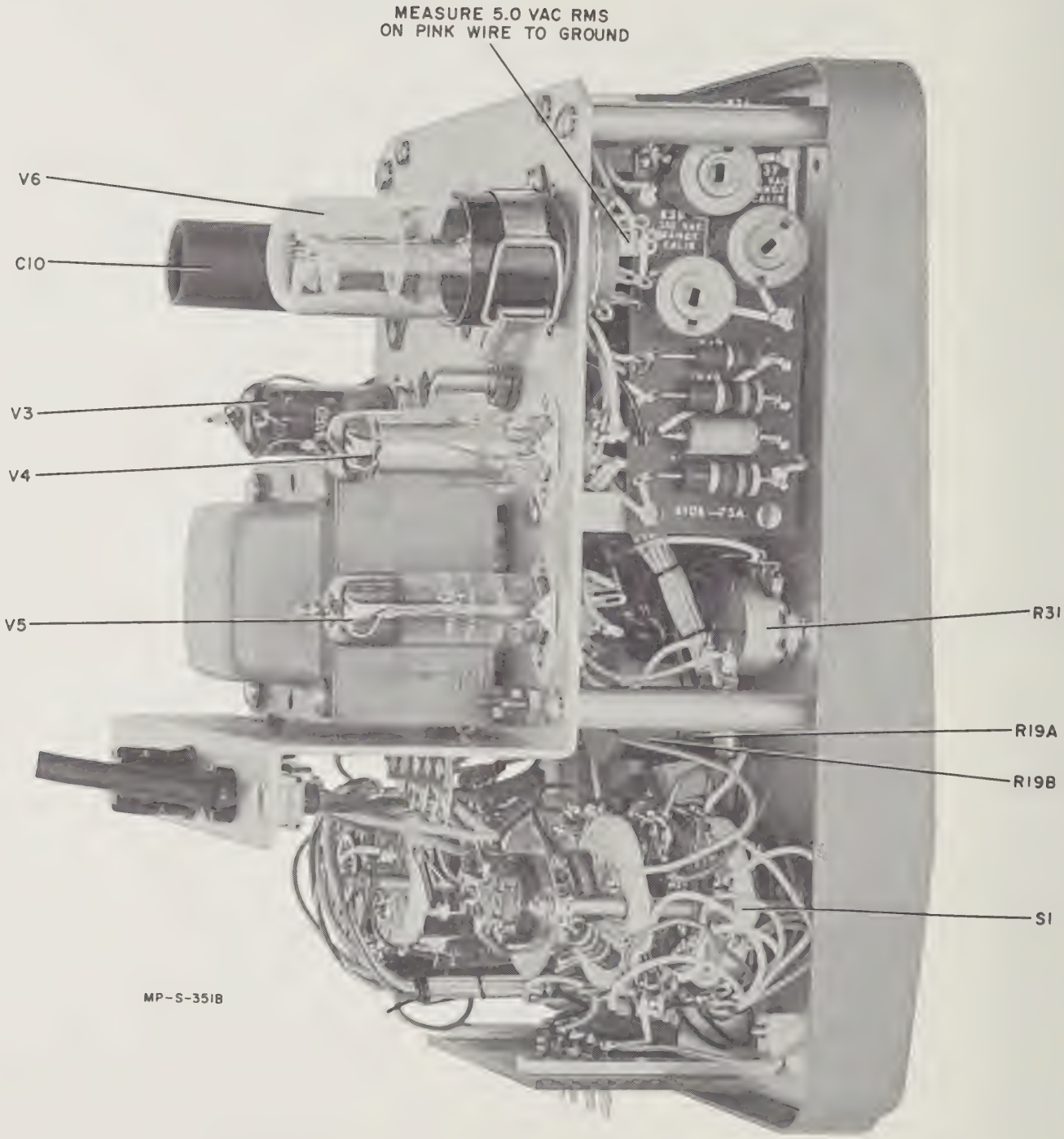


Figure 4-4. Left Side View of Model 410B

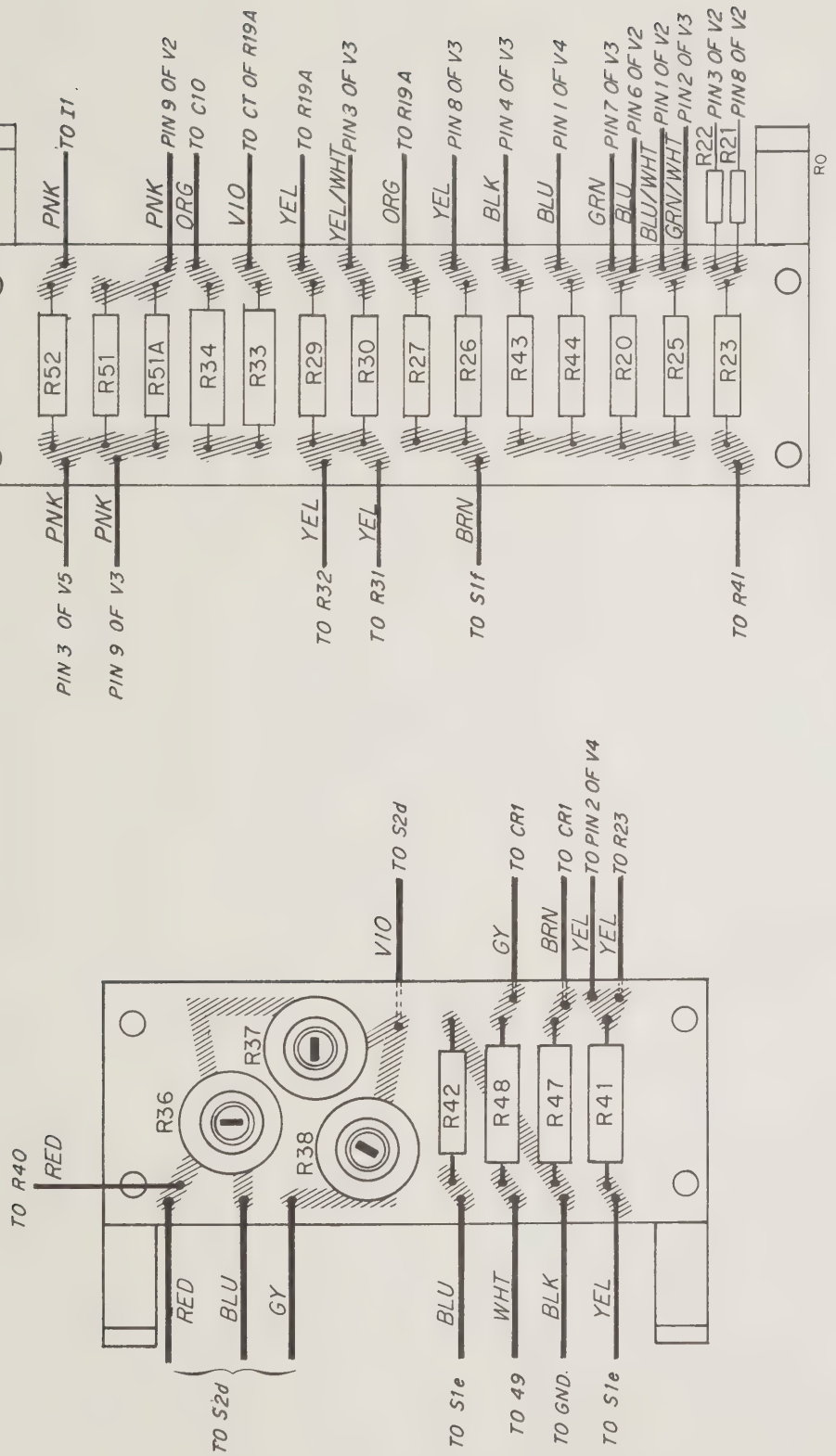


Figure 4-5. Resistor Board Details Model 410B

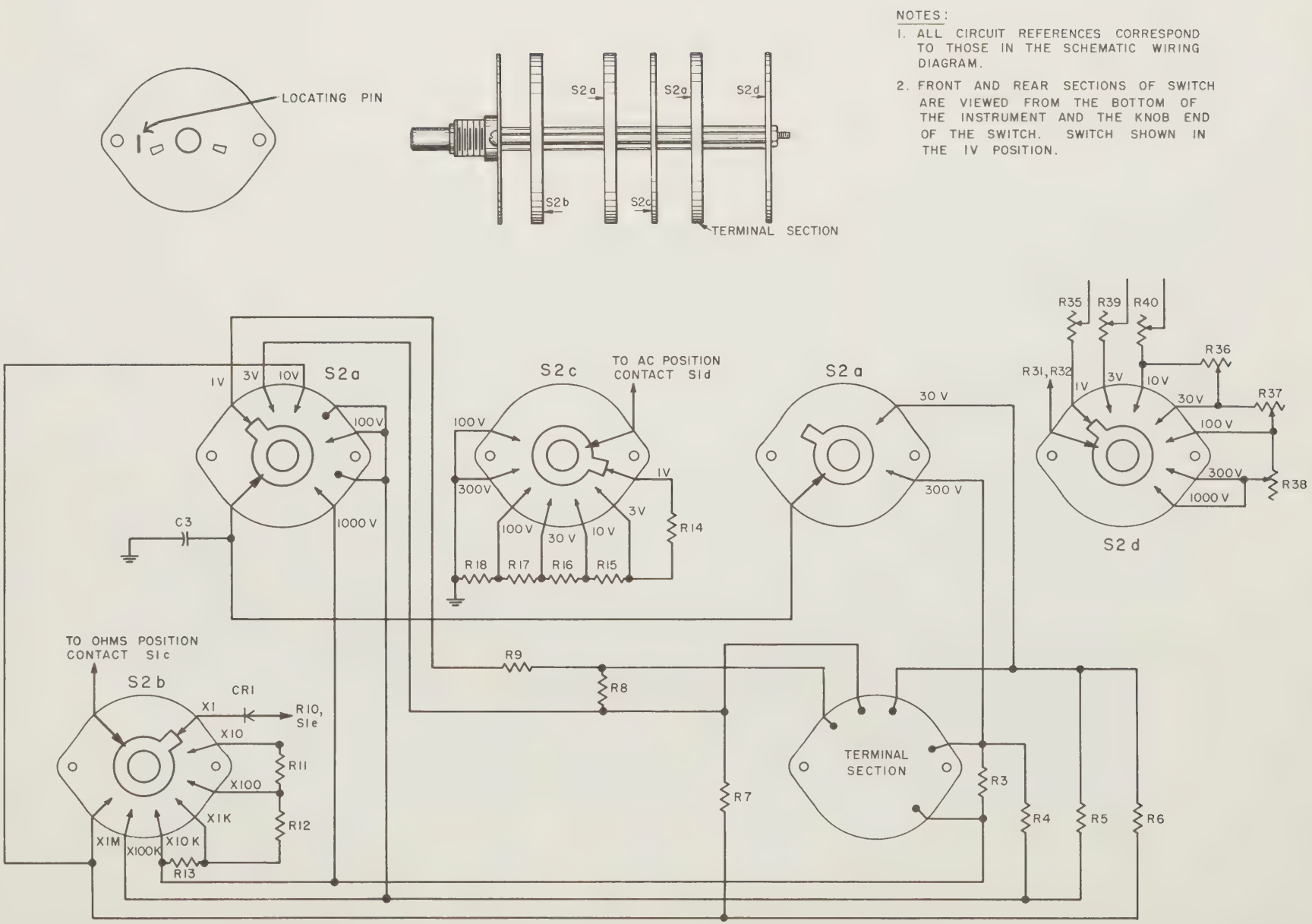
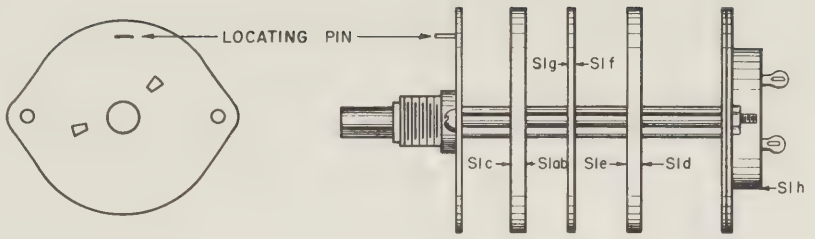
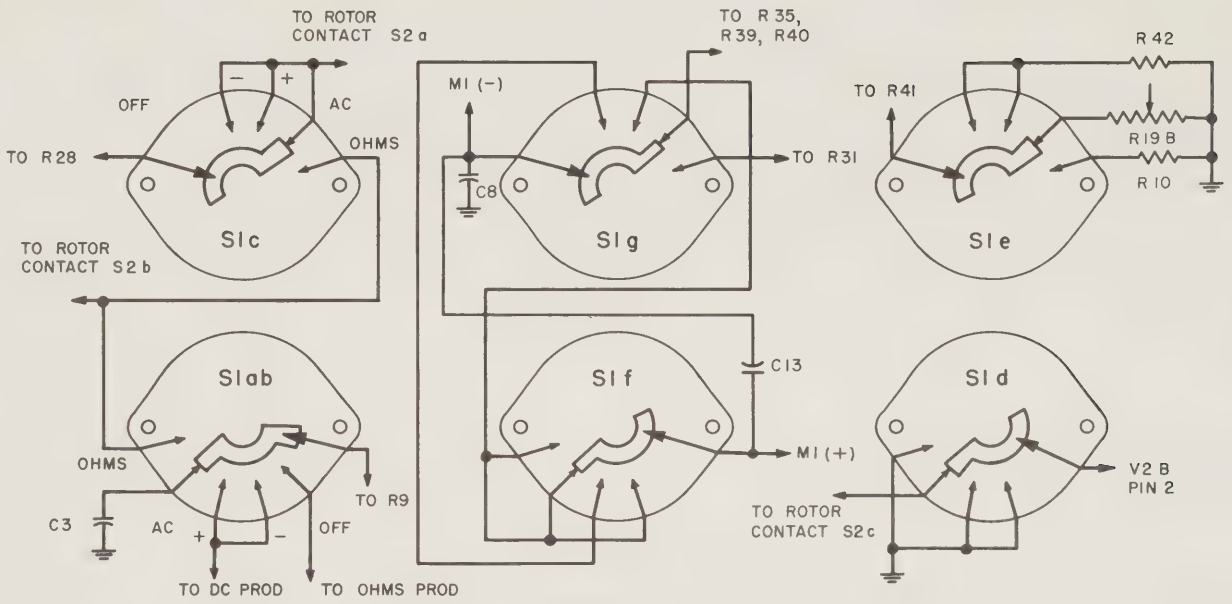


Figure 4-6. Range Switch Details Model 410B



NOTES:

1. ALL CIRCUIT REFERENCES CORRESPOND TO THOSE IN THE SCHEMATIC WIRING DIAGRAM.
2. FRONT AND REAR SECTIONS OF SWITCH ARE VIEWED FROM THE BOTTOM OF THE INSTRUMENT AND THE KNOB END OF THE SWITCH. SWITCH SHOWN IN THE AC POSITION.



MODEL 410 B
SELECTOR SWITCH DETAILS

Figure 4-7. Selector Switch Details Model 410B

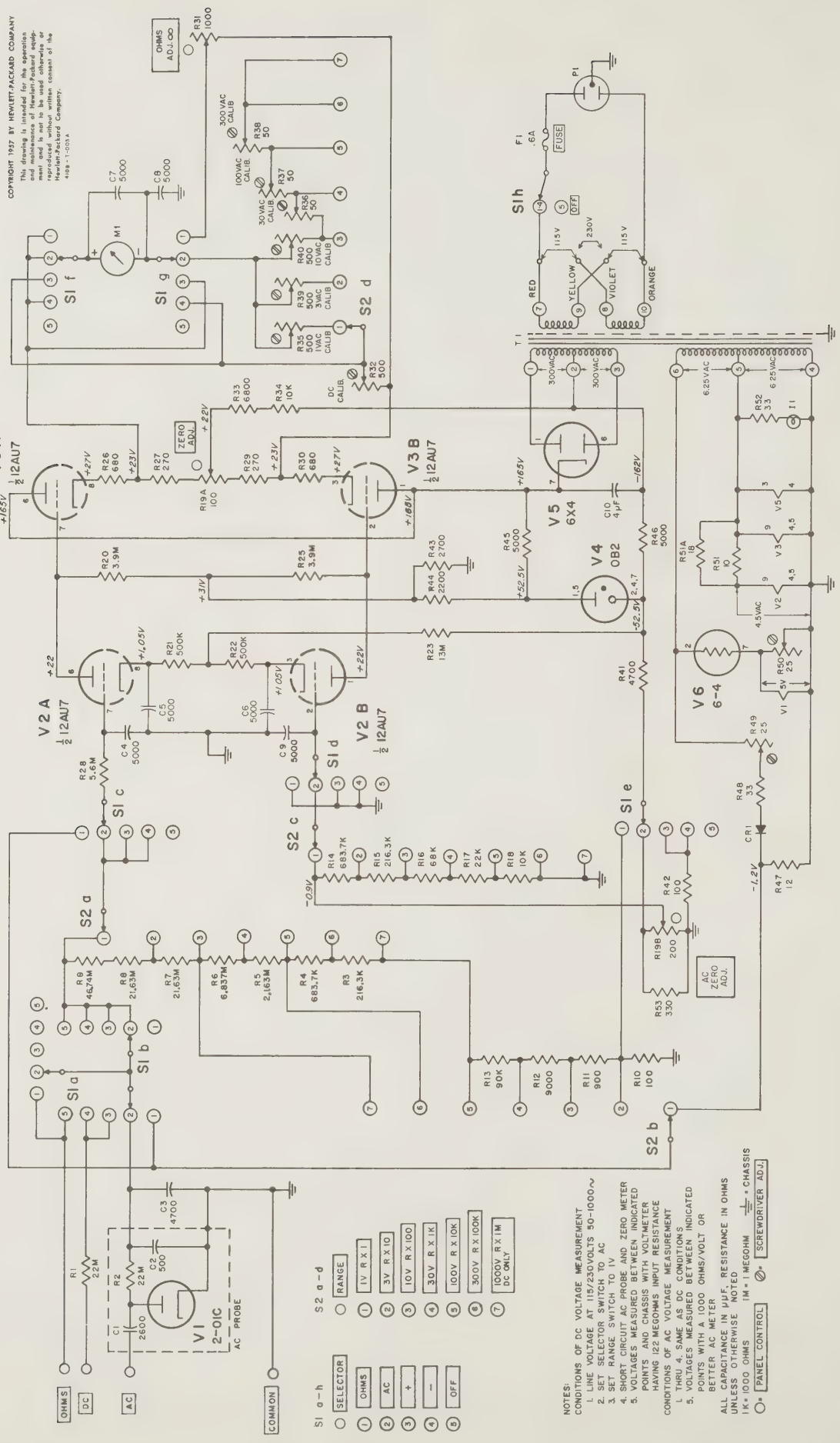


Figure 4-8 Schematic Diagram

SECTION V
TABLE OF REPLACEABLE PARTS

NOTE

Standard components have been used in this instrument, whenever possible. Special components may be obtained from your local Hewlett-Packard representative or from the factory.

When ordering parts always include:

1. ℎ𝑝 Stock Number.
2. Complete description of part including circuit reference.
3. Model number and serial number of instrument.
4. If part is not listed, give complete description, function and location of part.

Corrections to the Table of Replaceable Parts are listed on an Instruction Manual Change sheet at the front of this manual.

RECOMMENDED SPARE PARTS LIST

Column RS in the Table lists the recommended spare parts quantities to maintain one instrument for one year of isolated service. Order complete spare parts kits from the Factory Parts Sales Department. ALWAYS MENTION THE MODEL AND SERIAL NUMBERS OF INSTRUMENTS INVOLVED.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℗ STOCK NO.	TQ	RS		
C1, 2	Capacitors: part of AC probe						
C3	Capacitor: fixed, mica 4700 pf, 500 vdcw	V*	0140-0017	1	1		
C4 thru C9	Capacitor: fixed, ceramic .005 μf, 500 vdcw	K*	0150-0014	6	2		
C10	Capacitor: fixed, electrolytic, 4 μf, 450 vdcw	CC*	0180-0055	1	1		
CR1	Rectifier, metallic	Federal Tel & Radio	1880-0005	1	1		
F1	Fuse, cartridge: 0.6 amp, slow blow, for 115V operation	T*	2100-0016	1	10		
	Fuse, cartridge: 1/4 amp, slow blow, for 230V operation	E*	2100-0018				
I1	Lamp, incandescent: 6-8V .15 amp, #47	N*	2140-0009	1	1		
M1	Meter	HP*	1120-0009	1	1		
P1	Power cord	Elec. Cords Co.	8120-0050	1	1		
R1	Resistor: fixed, composition, 22 megohms, ±10%, 1 W part of Cable Assembly, DC probe	B*	0690-2261	2	1		
R2	Same as R1 (part of AC probe)						
R3	Resistor: fixed, deposited carbon, 216,300 ohms, ±1%, 1 W	HP*	0730-0079	1	1		
R4	Resistor: fixed, deposited carbon 683,700 ohms, ±1%, 1 W	HP*	0730-0096	1	1		
R5	Resistor: fixed deposited carbon, 2.163 megohms, ±1%, 1 W	HP*	0730-0113	1	1		
R6	Resistor: fixed, deposited carbon, 6.837 megohms, ±1%, 1 W	HP*	0730-0130	1	1		

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	TQ	RS		
R7, 8	Resistor: fixed, deposited carbon 21.63 megohms, ±1%, 2 W HP*	0733-0005	2	1		
R9	Resistor: fixed, deposited carbon, 46.74 megohms, ±1%, 2 W HP*	0733-0011	1	1		
R10	Resistor: fixed, deposited carbon, 100 ohms, ±1%, 1/2 W NN*	0727-0043	1	1		
R11	Resistor: fixed, deposited carbon, 900 ohms, ±1%, 1/2 W NN*	0727-0095	1	1		
R12	Resistor: fixed, deposited carbon, 9000 ohms, ±1%, 1/2 W NN*	0727-0152	1	1		
R13	Resistor: fixed, deposited carbon, 90,000 ohms, ±1%, 1/2 W NN*	0727-0203	1	1		
R14	Resistor: fixed, deposited carbon, 683,700 ohms, ±1%, 1/2 W HP*	0727-0251	1	1		
R15	Resistor: fixed, deposited carbon, 216,300 ohms, ±1%, 1/2 W HP*	0727-0223	1	1		
R16	Resistor: fixed, composition, 68,000 ohms, ±10%, 1/2 W B*	0687-6831	1	1		
R17	Resistor: fixed, composition, 22,000 ohms, ±10%, 1/2 W B*	0687-2231	1	1		
R18	Resistor: fixed, composition, 10,000 ohms, ±10%, 1/2 W B*	0687-1031	1	1		
R19 A,B	Resistor: variable, wirewound, 2 sections, front: 100 ohms, rear: 200 ohms BO*	2100-0050	1	1		
R20	Resistor: fixed, composition, 3.9 megohms, ±5%, 1 W B*	0689-3955	2	1		
R21, 22	Resistor: fixed, composition, 500,000 ohms, ±1% 1/2 W NN*	0727-0244	2	1		
R23	Resistor: fixed, composition, 13 megohms, ±5%, 1 W B*	0689-1365	1	1		
R24	This circuit reference not assigned					

* See "List of Manufacturers Code Letters For Replaceable Parts Table".

TQ - Total quantity used in the instrument.

RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	TQ	RS		
R25	Same as R20					
R26	Resistor: fixed, composition, 680 ohms, ±5%, 1 W B*	0689-6815	2	1		
R27	Resistor: fixed, composition, 270 ohms, ±5%, 1 W B*	0689-2715	2	1		
R28	Resistor: fixed, composition, 5.6 megohms, ±10%, 1/2 W B*	0687-5651	1	1		
R29	Same as R27					
R30	Same as R26					
R31	Resistor: variable, composition, linear taper, 1000 ohms ±20%, 1/2 W G*	2100-0036	1	1		
R32	Resistor: variable, composition, linear taper, 500 ohms ±30%, 1/4 W BO*	2100-0185	4	1		
R33	Resistor: fixed, composition, 6800 ohms, ±10%, 2 W B*	0693-6821	1	1		
R34	Resistor: fixed, composition, 10,000 ohms, ±10%, 2 W B*	0693-1031	1	1		
R35	Same as R32					
R36, 37, 38	Resistor: variable, wirewound, 50 ohms, ±10%, 1 W Mel-Rain Corp.	2100-0206	3	1		
R39, 40	Same as R32					
R41	Resistor: fixed, composition, 4700 ohms, ±10%, 2W B*	0693-4721	1	1		
R42	Resistor: fixed, composition, 100 ohms, ±10%, 1W B*	0690-1011	1	1		
R43	Resistor: fixed, composition, 2700 ohms, ±10%, 1W B*	0690-2721	1	1		
R44	Resistor: fixed, composition, 2200 ohms, ±10%, 1W B*	0690-2221	1	1		
R45, 46	Resistor: fixed, wirewound, 5000 ohms, ±10%, 10W S*	0816-0006	2	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**

TQ - **Total quantity used in the instrument.**

RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION	℗ STOCK NO.	TQ	RS		
R47	Resistor: fixed, wirewound, 12 ohms HP*	410B-26	1	1		
R48	Resistor: fixed, composition, 33 ohms, ±10%, 2W B*	0693-3301	1	1		
R49, 50	Resistor: variable, wirewound, 25 ohms, ±10%, 3W Precision Parts Co.	2100-0035	2	1		
R51	Resistor: fixed, composition, 10 ohms, ±10%, 1W B*	0690-1001	1	1		
R51A	Resistor: fixed, composition, 18 ohms, ±10%, 1W B*	0690-1801	1	1		
R52	Resistor: fixed, composition, 33 ohms, ±10%, 1W B*	0690-3301	1	1		
R53	Resistor: fixed, composition 330 ohms, ±10%, 1W B*	0690-3311	1	1		
S1A thru S1G	Selector Switch Assembly HP* Switch, rotary: less components W*	410B-19A 3100-0065	1 1	1		
S1H	Switch, power: rear section of selector switch W*	3130-0030				
S2	Range Switch Assembly HP*	410B-19W	1	1		
T1	Transformer, power HP*	910-73	1	1		
V1	Tube, electron: 2-01C HP*	212-2-01C	1	1		
V2, 3	Tube, electron: 12AU7 HP* Tubes selected for best performance will be supplied by ℗ (if ordered by ℗ Stock No.), but tubes meeting EIA standards will normally result in the instrument operating within specifications.	G-73R	2	2		
V4	Tube, electron: OB2 ZZ*	1940-0007	1	1		
V5	Tube, electron: 6X4 ZZ*	1930-0016	1	1		
V6	Tube, ballast: #6-4 C*	0852-0003	1	1		

*** See "List of Manufacturers Code Letters For Replaceable Parts Table".**
TQ- Total quantity used in the instrument.
RS- Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℗ STOCK NO.	TQ	RS		
	MISCELLANEOUS						
	Connector board: male	HP*	410B-76M	1	1		
	Holder, fuse:	T*	140-16	1	1		
	Indicator Lamp Assembly	II*	145-2	1	1		
	Knob: engraved AC	HP*	G-74AC	1	1		
	Knob: SELECTOR, RANGE	HP*	G-74N	2	1		
	Knob: ZERO ADJ.	HP*	G-74J	1	1		
	Knob: OHMS ADJ.	HP*	G-74C	1	1		
	The numbers shown in the circuit reference column identify the following parts on the Complete Probe Assembly drawing.						
	Assembly, Test lead, includes AC probe (less diode) DC probe, Ohms probe, Common Lead, female connector board and shield	HP*	410B-21-95A				
	Assembly, AC probe (less diode) with cable	HP*	410B-21-95B				
	Assembly, DC probe with cable	HP*	410B-21-95C				
	Assembly, Ohms probe with cable	HP*	410B-21-95D				
	Assembly, Common Lead	HP*	410B-21-95E				
	NOTE: The numbers shown in the circuit reference column identify the following parts shown in Figure 4-1.						
1	Jumper, ground, for AC probe	HP*	410B-21J				
2	Clip, ground, for AC probe	HP*	410B-21H				
3	Probe head	HP*	410B-21D				
4	Sleeve, for AC probe	HP*	410B-21E				

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

TABLE OF REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION, MFR. * & MFR. DESIGNATION		℗ STOCK NO.	TQ	RS		
5	Screw, Machine, Fillister Head, No. 4-40 x 3/16 in.	HP*	2220-0001				
6	Assembly, probe contact, for AC Probe	HP*	410B-21C				
7	Tip, for probe diode	HP*	410B-21N				
8	Spring, contact	HP*	410B-21B-3A				
9	Tube, electron (see V1)						
10, 11, 12	Assembly, socket, for probe diode	HP*	410B-21B				
13	Clip, alligator	HP*	1400-0046				
14	Cable, black, 48 in.	HP*	8160-0001				
15	Needle, phono	HP*	1490-0013				
16, 17, 19	Body, DC probe	HP*	410B-21L				
18	Resistor: fixed, composition, (see R1)						
20	Nut	HP*	410B-21K				
21	Cable, coaxial, 48 in.	HP*	8120-0003				
22	Same as 15						
23, 24, 25	Body, Ohms probe	HP*	1490-0011				
26	Cable, red, 48 in.	HP*	8160-0002				
27	Nut, No. 4-40 x 3/16 in.	HP*	2340-0001				
28	Washer, lock, No. 4, 1/16 in.	HP*	2190-0003				
29	Washer, fiber, extruded	HP*	3050-0005				
30	Connector, female board	HP*	410B-76F				
31	Shield, test lead terminal board	HP*	410B-55				
32	Screw, Machine, Round head, No. 6-32 x 1-1/8 in.	HP*	2360-0015				
33	Screw, Machine, Fillister Head, No. 4-40 x 3/4 in.	HP*	2220-0006				
34	Washer, flat, steel, No. 6	HP*	3050-0016				

* See "List of Manufacturers Code Letters For Replaceable Parts Table".
TQ - Total quantity used in the instrument.
RS - Recommended spares for one year isolated service for one instrument.

LIST OF CODE LETTERS USED IN TABLE OF REPLACEABLE PARTS TO DESIGNATE THE MANUFACTURERS

CODE LETTER	MANUFACTURER	ADDRESS
A	Aerovox Corp.	New Bedford, Mass.
B	Allen-Bradley Co.	Milwaukee 4, Wis.
C	Amperite Co.	New York, N. Y.
D	Arrow, Hart & Hegeman	Hartford, Conn.
E	Bussman Manufacturing Co.	St. Louis, Mo.
F	Carborundum Co.	Niagara Falls, N. Y.
G	Centralab	Milwaukee 1, Wis.
H	Cinch-Jones Mfg. Co.	Chicago 24, Ill.
HP	Hewlett-Packard Co.	Palo Alto, Calif.
I	Clarostat Mfg. Co.	Dover, N. H.
J	Cornell Dubilier Elec. Co.	South Plainfield, N. J.
K	Hi-Q Division of Aerovox	Olean, N. Y.
L	Erie Resistor Corp.	Erie 6, Pa.
M	Fed. Telephone & Radio Corp.	Clifton, N. J.
N	General Electric Co.	Schenectady 5, N. Y.
O	General Electric Supply Corp.	San Francisco, Calif.
P	Girard-Hopkins	Oakland, Calif.
Q	Industrial Products Co.	Danbury, Conn.
R	International Resistance Co.	Philadelphia 8, Pa.
S	Lectrohm Inc.	Chicago 20, Ill.
T	Littlefuse Inc.	Des Plaines, Ill.
U	Maguire Industries Inc.	Greenwich, Conn.
V	Micamold Radio Corp.	Brooklyn 37, N. Y.
W	Oak Manufacturing Co.	Chicago 10, Ill.
X	P. R. Mallory Co., Inc.	Indianapolis, Ind.
Y	Radio Corp. of America	Harrison, N. J.
Z	Sangamo Electric Co.	Marion, Ill.
AA	Sarkes Tarzian	Bloomington, Ind.
BB	Signal Indicator Co.	Brooklyn 37, N. Y.
CC	Sprague Electric Co.	North Adams, Mass.
DD	Stackpole Carbon Co.	St. Marys, Pa.
EE	Sylvania Electric Products Co.	Warren, Pa.
FF	Western Electric Co.	New York 5, N. Y.
GG	Wilkor Products, Inc.	Cleveland, Ohio
HH	Amphenol	Chicago 50, Ill.
II	Dial Light Co. of America	Brooklyn 37, N. Y.
JJ	Leecraft Manufacturing Co.	New York, N. Y.
KK	Switchcraft, Inc.	Chicago 22, Ill.
LL	Gremar Manufacturing Co.	Wakefield, Mass.
MM	Carad Corp.	Redwood City, Calif.
NN	Electra Manufacturing Co.	Kansas City, Mo.
OO	Acro Manufacturing Co.	Columbus 16, Ohio
PP	Alliance Manufacturing Co.	Alliance, Ohio
QQ	Arco Electronics, Inc.	New York 13, N. Y.
RR	Astron Corp.	East Newark, N. J.
SS	Axel Brothers Inc.	Long Island City, N. Y.
TT	Belden Manufacturing Co.	Chicago 44, Ill.
UU	Bird Electronics Corp.	Cleveland 14, Ohio
VV	Barber Colman Co.	Rockford, Ill.
WW	Bud Radio Inc.	Cleveland 3, Ohio
XX	Allen D. Cardwell Mfg. Co.	Plainville, Conn.
YY	Cinema Engineering Co.	Burbank, Calif.
ZZ	Any brand tube meeting RETMA standards.	
AB	Corning Glass Works	Corning, N. Y.
AC	Dale Products, Inc.	Columbus, Neb.
AD	The Drake Mfg. Co.	Chicago 22, Ill.
AE	Elco Corp.	Philadelphia 24, Pa.
AF	Hugh H. Eby Co.	Philadelphia 44, Pa.
AG	Thomas A. Edison, Inc.	West Orange, N. J.
AH	Fansteel Metallurgical Corp.	North Chicago, Ill.
AI	General Ceramics & Steatite Corp.	Keasbey, N. J.
AJ	The Gudeman Co.	Sunnyvale, Calif.
AK	Hammerlund Mfg. Co., Inc.	New York 1, N. Y.
AL	Industrial Condenser Corp.	Chicago 18, Ill.
AM	Insuline Corp. of America	Manchester, N. H.
AN	Jennings Radio Mfg. Corp.	San Jose, Calif.
AO	E. F. Johnson Co.	Waseca, Minn.
AP	Lenz Electric Mfg. Co.	Chicago 47, Ill.
AQ	Micro-Switch	Freeport, Ill.
AR	Mechanical Industries Prod. Co.	Akron 8, Ohio
AS	Model Eng. & Mfg., Inc.	Huntington, Ind.
AT	The Muter Co.	Chicago 5, Ill.
AU	Ohmite Mfg. Co.	Skokie, Ill.
AV	Resistance Products Co.	Harrisburg, Pa.
AW	Radio Condenser Co.	Camden 3, N. J.
AX	Shallcross Manufacturing Co.	Collingdale, Pa.
AY	Solar Manufacturing Co.	Los Angeles 58, Calif.
AZ	Sealectro Corp.	New Rochelle, N. Y.
BA	Spencer Thermostat	Attleboro, Mass.
BC	Stevens Manufacturing Co.	Mansfield, Ohio
BD	Torrington Manufacturing Co.	Van Nuys, Calif.
BE	Vector Electronic Co.	Los Angeles 65, Calif.
BF	Weston Electrical Inst. Corp.	Newark 5, N. J.
BG	Advance Electric & Relay Co.	Burbank, Calif.
BH	E. I. DuPont	San Francisco, Calif.
BI	Electronics Tube Corp.	Philadelphia 18, Pa.
BJ	Aircraft Radio Corp.	Boonton, N. J.
BK	Allied Control Co., Inc.	New York 21, N. Y.
BL	Augat Brothers, Inc.	Attleboro, Mass.
BM	Carter Radio Division	Chicago, Ill.
BN	CBS Hytron Radio & Electric	Danvers, Mass.
BO	Chicago Telephone Supply	Elkhart, Ind.
BP	Henry L. Crowley Co., Inc.	West Orange, N. J.
BQ	Curtiss-Wright Corp.	Carlstadt, N. J.
BR	Allen B. DuMont Labs	Clifton, N. J.
BS	Excel Transformer Co.	Oakland, Calif.
BT	General Radio Co.	Cambridge 39, Mass.
BU	Hughes Aircraft Co.	Culver City, Calif.
BV	International Rectifier Corp.	El Segundo, Calif.
BW	James Knights Co.	Sandwich, Ill.
BX	Mueller Electric Co.	Cleveland, Ohio
BY	Precision Thermometer & Inst. Co.	Philadelphia 30, Pa.
BZ	Radio Essentials Inc.	Mt. Vernon, N. Y.
CA	Raytheon Manufacturing Co.	Newton, Mass.
CB	Tung-Sol Lamp Works, Inc.	Newark 4, N. J.
CD	Varian Associates	Palo Alto, Calif.
CE	Victory Engineering Corp.	Union, N. J.
CF	Weckesser Co.	Chicago 30, Ill.
CG	Wilco Corporation	Indianapolis, Ind.
CH	Winchester Electronics, Inc.	Santa Monica, Calif.
CI	Malco Tool & Die	Los Angeles 42, Calif.
CJ	Oxford Electric Corp.	Chicago 15, Ill.
CK	Camloc-Fastener Corp.	Paramus, N. J.
CL	George K. Garrett	Philadelphia 34, Pa.
CM	Union Switch & Signal	Swissvale, Pa.
CN	Radio Receptor	New York 11, N. Y.
CO	Automatic & Precision Mfg. Co.	Yonkers, N. Y.
CP	Bassick Co.	Bridgeport 2, Conn.
CQ	Birnbach Radio Co.	New York 13, N. Y.
CR	Fischer Specialties	Cincinnati 6, Ohio
CS	Telefunken (c/o MVM, Inc.)	New York, N. Y.
CT	Potter-Brumfield Co.	Princeton, Ind.
CU	Cannon Electric Co.	Los Angeles, Calif.
CV	Dynac, Inc.	Palo Alto, Calif.
CW	Good-All Electric Mfg. Co.	Ogallala, Nebr.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number and serial number when referring to this instrument for any reason.

WARRANTY

Hewlett-Packard Company warrants each instrument manufactured by them to be free from defects in material and workmanship. Our liability under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose and to replace any defective parts thereof. Klystron tubes as well as other electron tubes, fuses and batteries are specifically excluded from any liability. This warranty is effective for one year after delivery to the original purchaser when the instrument is returned, transportation charges prepaid by the original purchaser, and when upon our examination it is disclosed to our satisfaction to be defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost. In this case, an estimate will be submitted before the work is started.

If any fault develops, the following steps should be taken:

1. Notify us, giving full details of the difficulty, and include the model number and serial number. On receipt of this information, we will give you service data or shipping instructions.

2. On receipt of shipping instructions, forward the instrument prepaid, to the factory or to the authorized repair station indicated on the instructions. If requested, an estimate of the charges will be made before the work begins provided the instrument is not covered by the warranty.

SHIPPING

All shipments of Hewlett-Packard instruments should be made via Truck or Railway Express. The instruments should be packed in a strong exterior container and surrounded by two or three inches of excelsior or similar shock-absorbing material.

DO NOT HESITATE TO CALL ON US

HEWLETT-PACKARD COMPANY
Laboratory Instruments for Speed and Accuracy
275 PAGE MILL ROAD PALO ALTO, CALIF. U.S.A.
CABLE "HEWPACK"

SERVICE NOTES
HEWLETT-PACKARD COMPANY • 275 PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U. S. A.
CABLE "HEWPACK" TELEPHONE DAVENPORT 5-4451

410B-2A

410A AND 410B VACUUM TUBE VOLTMETERS

AC PROBE DIODE REPLACMENT PROCEDURE

The following procedure is recommended when replacing the Stock No. 212-2-01C High Frequency Vacuum Tube Diode in the AC Probe of the Models 410A and 410B Vacuum Tube Voltmeter.

INSTALL THE REPLACEMENT DIODE

A procedure for mechanical replacement of the high frequency diode is not necessary. The rear cap and the outer shell or sleeve should not be permitted to rotate with respect to each other when loosening or tightening the knurled retainer ring holding these two parts together. This precaution is necessary to prevent possible internal damage should the socket assembly rotate with respect to the sleeve.

ADJUST THE HEATER VOLTAGE

Set the Voltmeter to the 1 volt AC range and turn on power. Set the heater current control, R50, to obtain 5.0 volts rms across the diode heater. This ac voltage can be measured between pin 7 of ballast tube V6 and chassis ground. Readjust the heater voltage, if necessary, after the voltmeter has been operating for at least 15 minutes.

CHECK ZERO ADJUSTMENT

Check that it is possible to set the meter pointer to zero with the AC Zero control after setting to zero with the DC Zero control. This test is necessary only on the 1 volt range. The AC Zero control electrical range can be adjusted by changing the value of resistor R53. A value of 330 ohms, ±10%, 1 watt is recommended for R53. This 1 watt resistor is connected in parallel with the AC Zero control and is mounted on the rear wafer of the Range Selector Switch.

RECALIBRATE AC RANGES

For maximum voltmeter accuracy, check the calibration of the AC ranges as described in the Operating and Servicing Manual. If calibration above 400 megacycles is required, refer to Service Note 410A-6 for complete instructions.

distribution f

MANUAL CHANGES

MODEL 410B

HIGH FREQUENCY VACUUM TUBE VOLTMETER

Manual printed: 6-60
For Serials Prefixed: 024-

ERRATA in the Table of Replaceable Parts:

F1: Change -hp- Stock No. for 0.6 amp fuse to 2110-0016.
Change -hp- Stock No. for ¼ amp fuse to 2110-0018.

Page V-7:
Delete item 8 description. Item 8 is part of item 7.
Change item 12 to ring, retaining; -hp- Stock No. 410B-21F. This is not included as part of the diode socket assembly as indicated.

V1: Change to tube, electron, 2-01C or EA53; -hp- Stock No. 1920-0010, Mfr., HP

For instruments equipped with EA53 probe diode:

The tip and spring for probe diode (items 7 and 8 on page V-7) are available under -hp- Stock No. 410B-21P, Mfr., HP

ERRATA in the Table of Replaceable Parts, under MISCELLANEOUS:

Fuseholder: Change -hp- Stock No. to read 1400-0084.

Add the following under step 4 of paragraph 4-2 (Replacing V1):
If EA53 probe diode is used, adjust R50 to obtain 6.3 volts rms.

Two different types of probe diode tubes are available for V1: the 2-01C (-hp- Stock No. 1920-0008) manufactured by Eitel-McCullough, Inc., and the EA53 (-hp- Stock No. 1920-0010) manufactured by Amperex Electronic Co. These tubes are interchangeable; however, each type requires a different plate contact and attaching spring, and a different heater voltage. The proper plate contact and spring are supplied with each replacement diode (-hp- Stock

No. 410B-21P for the EA53; 410B-21N for the 2-01C). The proper voltage for the 2-01C is 5 volts rms; for the EA53, 6.3 volts rms. When the type of diode is changed, minor adjustment of R50 may be required to obtain exact heater voltage.

